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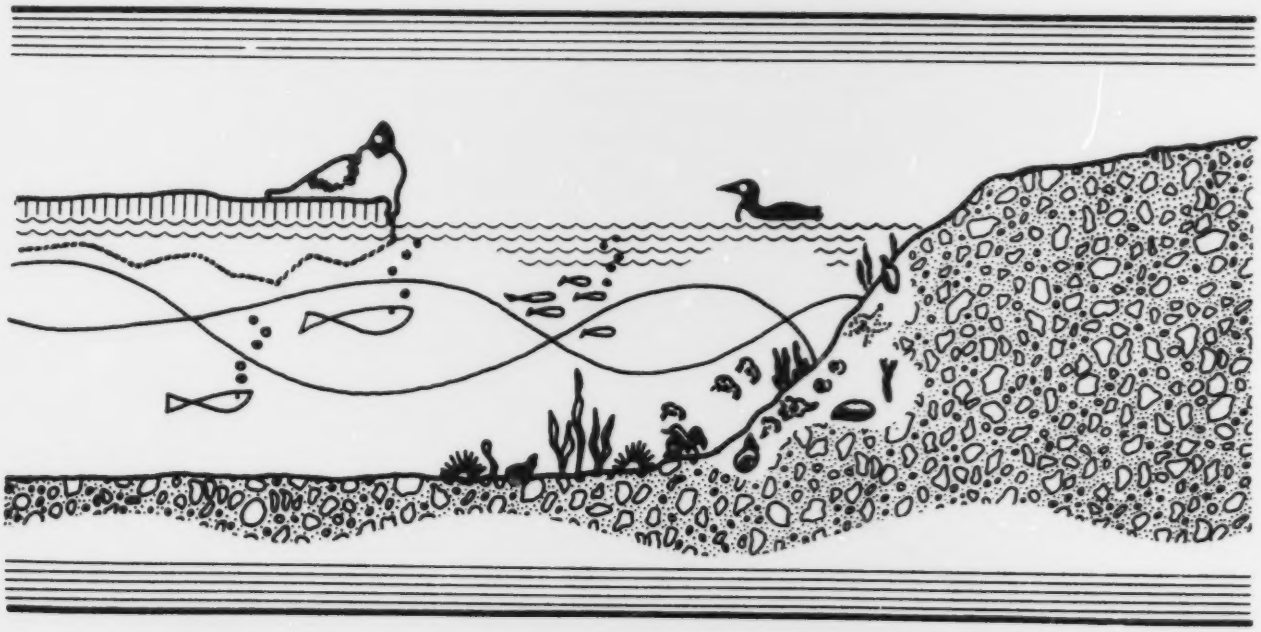

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Baffin Island Oil Spill Project

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BAFFIN ISLAND OIL SPILL PROJECT
WORKING REPORT SERIES

The Baffin Island Oil Spill (BIOS) Project is a multidisciplinary program of research on arctic marine oilspill fate, effects and countermeasures. The Project commenced in the spring of 1980 and have now completed the fourth and final year of planned field work at an experimental site located on the northern end of Baffin Island, Canada. The results of work performed in each of the various study components under the Project, has been made available on a yearly basis through this working report series. This has been done prior to a complete integration of findings and interpretation with respect to the Project objectives. The working report series should therefore be considered as interim or data reports. The contents do not necessarily reflect the views for policies of the BIOS Project management or funders.

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EFFECTS OF OIL AND DISPERSED OIL ON NEARSHORE MACROBENTHOS AT CAPE HATT, NORTHERN BAFFIN ISLAND. IV. RESULTS OF 1980, 1981, 1982 and 1983 PRE- AND POST-SPILL STUDIES

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EXECUTIVE SUMMARY

The objectives of the macrobiological component of the BIOS project were to assess the effects of oil and dispersed oil on the macrophytic algae, the relatively immobile benthic infauna (e.g., bivalves, polychaetes), and the motile epibenthos (e.g., amphipods, urchins) in shallow arctic waters. Four bays at Cape Hatt, northern Baffin Island, were selected as experimental bays. During August 1981, 15 m^3 of Lagomedio crude oil was applied to the surface of one bay, and 15 m^3 of dispersed oil (10 Lagomedio : 1 Corexit 9527) was released underwater in another bay. The latter release also resulted in relatively heavy contamination of the third study bay, and low levels of contamination in the surface oil release bay and in the fourth (reference) bay. Systematic sampling was carried out in these bays during each of the two ice-free months (August and September) between September 1980 and August 1983.

Methods. -- Three transects were sampled at each of two depths (3 m, 7 m) in each of the four bays over four open water periods. The work on each transect included collection of (1) eight replicate samples, each covering 0.0625 m^2, using a diver-operated airlift sampler, (2) 8-12 photographs, each covering 0.25 m^2, and (3) five _in situ_ counts of large organisms within areas 1 x 10 m in dimensions. Photographs and direct counts of animals on the substrate surface along the standard transects were also obtained within five days of the dispersed oil release. All fauna $\geq$1 mm in length were sorted from airlift samples, identified to species where possible, counted and weighed. All bivalves and holothurians were measured, and wet and dry weights were obtained for a subsample of four dominant bivalve species from each bay and period. Macroalgae retained on a 1 mm sieve were sorted, identified to species where possible, and weighed. Photographs and _in situ_ counts were used to provide a permanent visual record of the study area and to enumerate large and widely distributed organisms.

To determine whether oil had an effect, we compared (1) temporal changes in the experimental (oil release) bays with temporal changes in the reference bay, and (2) temporal changes in the surface oil release bay with those in the dispersed oil bays. The analytical techniques employed were analysis of

variance and analysis of covariance. In statistical terms, a significant interaction between spatial and temporal effects indicated a possible oil effect. The nature of each significant interaction was examined in relation to the type of oil treatment (surface vs. dispersed) and the concentrations of oil, both in the water during and immediately after the oil releases, and in the subtidal sediments during 1981 to 1983. Variables examined included density and biomass of dominant infaunal taxa, biomass of four infaunal feeding guilds and of dominant macroalgal species, density of epibenthic echinoderms and crustaceans, infaunal community structure, population structure in selected species of amphipods and bivalves, and size and weight-length relationships in common bivalve species.

Differences Among Bays and Sampling Periods. — Most of the systematic variability identified by these analyses was spatial and temporal; little of the variation was attributable to oil effects. Nearly all variables differed significantly on small and large spatial scales (among-transects and among-bays, respectively). Significant temporal differences were less common and most often were annual rather than seasonal. There was some evidence of natural multi-year cycles in the nearshore marine benthic community.

Immediate Effects of Oil. — Oil effects were visually apparent on the first and second days following both oil releases in 1981. Only intertidal amphipods and some larval fish were obviously affected by the surface oil release; immediate and one year post-spill effects on intertidal amphipods are reported by Cross (1982) and Cross and Martin (1983). The dispersed oil release, however, produced marked immediate effects on benthos at both 3 and 7 m depths in both the release bay and the adjacent bay (difference of approximately an order of magnitude in dispersed oil levels). In these bays, a variety of large infaunal and epibenthic invertebrates, particularly the bivalve Serripes groenlandicus, emerged from the substrate and/or assumed unnatural postures. There was evidence of recovery in these animals, however, within two weeks of the oil release.

Analysis Results. — Over the two years following the releases, oil and dispersed oil caused some detectable effects on a small number of species, but did not cause large-scale mortality of benthic biota or any significant

change in benthic infaunal community structure. This lack of major effects was probably a result of the fact that hydrocarbon levels in the sediments were rather low, similar to those in 'lightly oiled' areas reported elsewhere. Significant oil effects were found in only 8 of 119 variables for which analyses were performed. Within the framework of published literature, our results are consistent with the low quantities of oil to which the animals were exposed.

Infauna. -- To test for subtle changes in infaunal density and biomass, we analyzed 28 species- or group-variables at 3 m depth, and 33 variables at 7 m depth. We found changes that might be related to oil in only one taxon at each of 3 m and 7 m depths. The polychaete Spio spp. was apparently affected by oil in sediments at 3 m depth in both the dispersed oil release and surface oil release bays. Breeding in two-year-olds or development of their offspring in the fall and winter following the oil releases was delayed in these two bays, whereas the year class that was produced in the oil release year was able to reproduce successfully (in 1982-1983) only in the reference bay. At 7 m depth, oil in the sediments of the surface oil release bay may have enhanced the settlement of juveniles of the bivalve genus Macoma in the summer of 1982, but the observed density increase was within the range of natural variability.

Data on mean size and population structure for four bivalve species and the holothurian Myriotrochus rinkii at Cape Hatt showed considerable spatial and temporal (seasonal and annual) variability. The only evidence of oil-related effects on size-frequency distributions was mortality of large Mya truncata at 3 m depth in Bay 11. The low numbers of individuals present, however, render this interpretation ambiguous. Most of the observed variability was likely attributable to natural variability (1) in recruitment of larvae with pelagic or direct development, (2) in growth rates, and/or (3) in mortality of young or old individuals.

Weight-length relationships in two of the four bivalve species examined were apparently affected by the experimental oil releases at Cape Hatt. In Macoma calcarea, the normal seasonal (August to September) increase in tissue weight relative to length occurred only in the reference bay. Macoma

calcarea is a deposit feeder, and high concentrations of oil were accumulated in its body tissues from sediments in the oiled bays during the two weeks adjusted for length decreased progressively in the reference bay following the dispersed oil release. Serripes groenlandicus accumulated more oil in this bay than in any other, probably because its filtering activity was impaired in bays where dispersed oil concentrations were high.

It is not known whether the observed sublethal effects will have any long-term effects at the population or community levels. However, in the two years following the experimental oil releases such effects were not evident. Multivariate analysis techniques provided no evidence that oil or dispersed oil affected infaunal community composition or the abundances of dominant infaunal species assemblages. Infaunal community structure in the study area changed during the four years of study, but this temporal change was similar in each bay and at both depths studied. The interval of greatest change was between September 1981 and September 1982.

Analysis of biomasses of four feeding guilds (filter feeders, deposit feeders, surface deposit feeders and carnivores) showed that temporal changes in biomass were either lacking or were consistent among bays. Thus, there was no evidence that any particular feeding guild was especially sensitive to the experimental oil releases. Nearly all of the variation in the four infaunal feeding guilds was spatial. This spatial variability was evident on both small (transect) and larger (bay) scales, and in all four feeding guilds.

Epibenthos. — We tested for subtle changes in densities of 11 epibenthic crustaceans at each of 3 and 7 m depths, and found changes that might be related to oil in only one taxon at 3 m depth. Length-frequency data provided more information on these density changes and indicated one other possible oil effect. In 1982, juveniles of the amphipod genus Anonyx apparently emigrated from 7 to 3 m depth earlier in the surface oil release bay than in the other bays. This may have been a behavioural response to the high levels of oil in the sediments of this bay. There was no indication that densities of the amphipod Pontoporeia femorata were affected by oil, but length-frequency data suggested that population structure was affected in the

surface oil release bay. The scarcity of newly-released juveniles in this bay during August 1983 indicated that reproduction in the previous winter may have been adversely affected by oil in sediments. Thus there were indications that the surface oil release had a delayed effect on two subtidal amphipod species one or two years after the oil release. No effect of dispersed oil on subtidal epibenthic crustaceans was detected.

Cross and Martin (1983) reported effects of the oil releases at Cape Hatt on the density, biomass and population structure of Gammarus setosus in under-ice and intertidal habitats. Direct oiling of intertidal populations in Bay 11 caused immediate mortality, particularly in the 0+ year class. This cohort was almost absent from the under-ice surface in the following spring but was well represented in the intertidal habitat one year following the oil release. These individuals must have been recruited from adjacent areas. The release of Gammarus juveniles on the under-ice surface in Bay 11 was delayed in spring 1982, and the 0+ year class was reduced in size in the intertidal habitat during the following August and September. The dispersed oil release, on the other hand, affected older Gammarus setosus (1 and 2+ year classes). Densities of these individuals were markedly reduced approximately one week following the release, but it is uncertain whether mortality or emigration was the cause of this decrease. Densities on the under-ice surface were low in both the pre- and the post-spill years. No effects of the dispersed oil release were apparent in abundance and population structure data collected in the intertidal habitat one year following the release.

The two large epibenthic echinoderms in the study area, Strongylocentrotus droebachiensis and Leptasterias polaris, were among the invertebrates that were apparently stressed immediately following the dispersed oil release. Analysis of density data showed no effect of dispersed oil on L. polaris, whereas effects on the density of S. droebachiensis were apparent. Urchins apparently emigrated actively from 7 m depth in the dispersed oil release bay to deeper, uncontaminated water. A movement from deep to shallow water in the adjacent bay may have occurred because dispersed oil entered that bay at a depth of approximately 8-10 m. In both bays, densities had returned to pre-spill levels within two weeks of the dispersed oil release. However, slightly reduced densities of urchins were found in

1983, possibly because of increased concentrations of oil in the sediments during 1983. The urchins probably emigrated to deeper water where sediments were cleaner.

Algae. — Biomasses of the dominant understory algae at 3 m depth did not seem to be adversely affected by either oil in sediments or oil in the water during the dispersed oil release. No oil effects were detected in data on biomass of total algae or of two of the three species that were analyzed. In a third species, Dictyosiphon foeniculaceus, growth may have been stimulated by low levels of oil in sediments during the year following the oil releases, although annual variability was another possible explanation for the observed biomass increases.

Dispersed vs. Untreated Oil. — The observed oil effects at Cape Hatt were associated with both untreated and chemically dispersed oil. The effects included sublethal effects and changes in abundance that were apparently caused by migration or reduced reproduction. Some of these effects appear to have been transitory, including immediate post-spill stress in a variety of benthic animals, temporary relocation of urchins, and changes in the abundance of amphipods. Other effects may persist or become more evident in subsequent years. These include changes in weight-length relationships in two bivalve species, and reduced reproduction in resident populations of amphipods and polychaetes that do not have planktonic larvae and, therefore, cannot recruit juveniles from the plankton.

Effects that may persist were found with both untreated and dispersed oil. Tissue weight in the deposit-feeding bivalve Macoma calcarea was adversely affected by high oil concentrations in sediments. In contrast, tissue weight in the filter-feeding Serripes groenlandicus was affected by low concentrations of dispersed oil in the water. Effects on reproduction of polychaetes and amphipods were apparently related to oil concentrations in sediments.

An important objective of the BIOS project was to compare oil effects in the dispersed oil release bay with those in the surface release bay and to make inferences about the effects of dispersing oil with chemical agents. To

this end, it is possible to say that the effects of dispersed oil have occurred and that they were minor. Immediate post-spill effects were obvious but temporary and appear to have had no permanent effect. Medium-term effects did not change community composition and affected only a few species.

In the surface oil release bay, no immediate effects on subtidal benthos were obvious, and medium-term effects were similar to those resulting from the dispersed oil treatment. Most of the few species that were affected responded to both types of oil treatment, indicating that oil in sediments, regardless of its source, was responsible for the observed effects. However, oil levels in the sediments of the study bays have not yet reached maximum levels (Boehm 1983). The increasing concentrations of oil in sediments may be sufficient to cause a further change in condition or reproductive status of benthic animals, and possibly even mortality, in the next year or two.

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SECTION ONE

INTRODUCTION

The Canadian Environmental Protection Service recently supported a multi-authored appraisal of the fate and effects of petroleum spilled in Canadian marine environments, and the use of chemical dispersants as a countermeasure (Sprague et al. 1981, 1982). Major data gaps identified therein concerned (1) the behaviour and effects of dispersants in general, (2) the fate and effects of oil in the Arctic, and (3) knowledge of natural processes in the marine environment, particularly in the Arctic. Many authors pointed out the difficulties in extrapolating from laboratory tests to field situation. Recently, considerable attention has been given to the effects of oil and dispersants on individual species of arctic marine flora and fauna under experimental conditions (Percy and Mullin 1975, 1977; Percy 1976, 1977, 1978; Busdosh and Atlas 1977; Malins 1977; Atlas et al. 1978; Foy 1978, 1979; Hsiao et al. 1978), but to date the potential effects on whole communities are unknown.

During recent oil spill investigations following the grounding of the tanker TSESIS in the Baltic Sea, a comparison of approaches toward detecting biological effects supported the 'ecosystem approach' advocated by Mann and Clark (1978): data on reproductive abnormalities in a sensitive species only confirmed effects that were already obvious at the community level (Elmgren et al. 1980). In temperate waters, community studies have been carried out for up to 10 years after a spill (e.g. Sanders et al. 1980), but most of these studies have been after the fact; hence, they lack adequate 'control' data on pre-spill conditions, on naturally occurring changes that would have occurred in the absence of the spill, or both (National Academy of Sciences 1975; cf. Bowman 1978). Another shortcoming of many spill studies has been the lack of supporting data on oceanographic and atmospheric conditions, and on hydrocarbon concentrations in the impacted environment (National Academy of Sciences 1975).

To date, no major oil spill has occurred in Canadian arctic waters. In 1978-1979 the Arctic Marine Oil Spill Program (AMOP) examined the need for research associated with experimental oilspills in cold Canadian waters, and thereafter instigated the Baffin Island Oil Spill (BIOS) project to study a controlled introduction of oil and dispersed oil onto shorelines and into nearshore arctic waters. The objectives of this project were to (1) compare the fate and effects of dispersed oil with the fate and effects of a beached surface slick in order to assess whether the use of chemical dispersants as a countermeasure would increase or decrease the impact of oil on the nearshore environment, and (2) to assess the relative effectiveness and impact of other shoreline protection and clean-up techniques. The BIOS project is an internationally funded, multidisciplinary study being carried out by engineers, meteorologists, physical oceanographers, geologists, chemists and biologists from various government departments, industry and research organizations. The nearshore component of the BIOS project includes studies of microbiology and benthic macrobiology, atmospheric and oceanographic conditions, and chemical properties of the water column and surface sediments, with special emphasis on concentrations of petroleum hydrocarbons.

The objectives of the macrobiological component of the BIOS project are to assess the effects of oil and dispersed oil on the macrophytic algae, the relatively immobile benthic infauna (e.g., bivalves, polychaetes), and the motile epibenthos (e.g., amphipods, urchins) in shallow arctic waters. The original design of the study was for oil to be released onto the surface in Bay 11, for dispersed oil to be released in Bay 9, and for Bay 10 to be maintained as an untreated control. Variables to be examined include total abundance, total biomass and structure of these communities, as well as the abundance, biomass, population age structure and length-weight relationships of dominant species in these communities. The statistical design of the study is 'optimal' for impact assessment, in the sense of Green (1979), in that it includes both temporal (pre-spill) and spatial (unoiled bay) controls.

Cross and Thomson (1981) provided baseline data from three bays at Cape Hatt, Baffin Island (Bays 9, 10 and 11; Fig. 1), during the first of two pre-spill sampling periods (September 1980). In anticipation of the

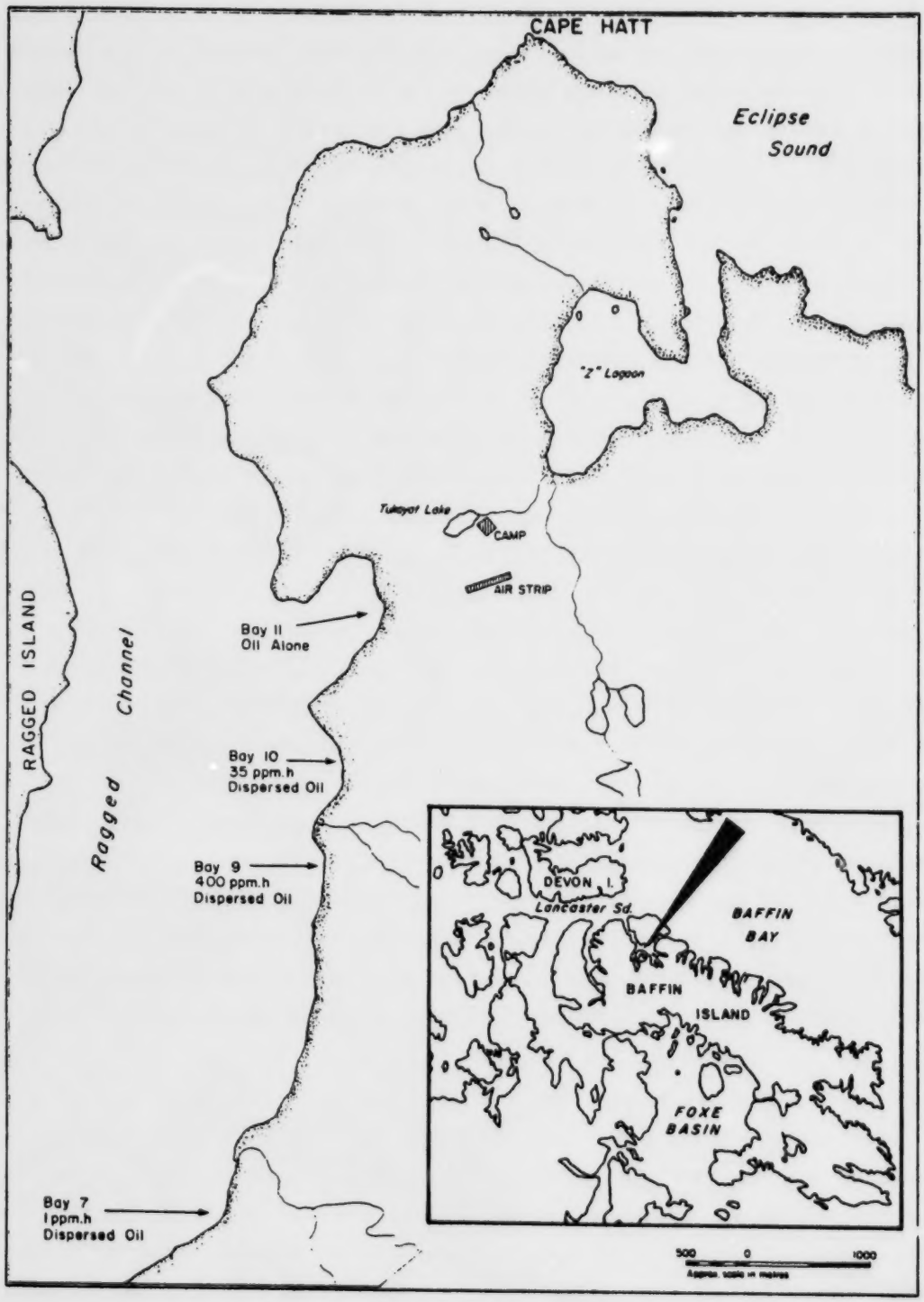


Figure 1. **BIOS site at Cape Hatt, Baffin Island, showing the locations of study bays and oil treatments applied in August 1981. Dispersed oil concentrations are maximum estimated exposures in ppm x hours.**

possibility of cross-contamination of the original control bay, a fourth bay remote from the spill site was added to the study design. All four bays were sampled during the second pre-spill sampling period (August 1981). In late August 1981, 15 m^3 of untreated Lagomedio oil was released within booms on the surface of Bay 11, and an additional 15 m^3 of the same oil treated with the dispersant Corexit 9527 (10 oil : 1 Corexit) was released underwater in Bay 9 (Fig. 1). Currents carried the dispersed oil through the study areas of Bays 9 and 10, and subsequently throughout the surface waters (10-15 m) of Ragged Channel. Exposures were relatively high and variable in Bay 9--300 ± 100 ppm-h over a 36 h period, with sustained average maximum of about 50 ppm. Exposures in Bay 10 were approximately an order of magnitude lower. In Ragged Channel, including Bays 7 and 11, oil concentrations were measured at 0.05 ppm, and exposure was estimated at 1 ppm-h over a 36 h period. The first post-spill sampling was carried out in September 1981 in all four bays.

Cross and Thomson (1982) reported observations and quantitative data on immediate post-spill effects, and provided an analysis of the effects of oil and dispersed oil based on two pre-spill sampling periods (September 1980 and August 1981) and one post-spill sampling period (September 1981). The third year's report (Cross et al. 1983) included data from 1982 (August and September sampling periods, approximately one year following the oil release) and provided an analysis of the effects of oil and dispersed oil based on the two pre-spill and three post-spill sampling periods. The present report includes data from August 1983 (2 years post-spill) and analyses which are based on the entire study period (September 1980 to August 1983).

SECTION TWO

METHODS

2.1 Study Area

The study area for the nearshore component of the Baffin Island Oil Spill Project consisted of four shallow embayments in Ragged Channel, some 5-8 km SSE of Cape Hatt, Eclipse Sound (72°27'N, 79°51'W). Bays 9 and 10 (dispersed oil release and dispersed oil contamination bays, respectively) are shallow indentations in the coastline, each about 500 m in length, separated by the delta of a small stream and a distance of somewhat less than 500 m. Bay 7 (reference bay) is similar in size and configuration, located about 6 km to the south, and just south of another small stream. Bay 11 (surface oil release bay) has been designated as the lower half (and Bay 12 as the upper half) of a deeper embayment approximately 1 km x 1 km in dimensions, located approximately 1 km north of Bay 10 (Fig. 1).

2.2 Field Procedures

Observations were made using SCUBA in the study bays during 7 August to 17 September 1980, 5 August to 20 September 1981, 30 July to 13 September 1982 and 3-29 August 1983. Divers monitored each oil release in 1981 and the condition of each bay on the first day following the dispersed oil release. Systematic sampling was carried out during 29 August-17 September 1980, 6-17 August 1981, 29 August-10 September 1981, 8-15 August 1982, 3-12 September 1982 and 6-10 August 1983 from the BIOS project camp located at Cape Hatt, Baffin Island (Fig. 1). Additional sampling for other studies continued between the two periods in 1981 and 1982 and until 20 September 1981, 13 September 1982 and 29 August 1983. All sampling was carried out by divers working from inflatable boats. Processing and preservation of samples were performed in tents erected on the beach in Bay 12. During September 1980, systematic sampling was carried out in Bays 9, 10 and 11, and during August and September 1981 and 1982, and August 1983, systematic sampling was carried out in Bays 7, 9, 10 and 11 (Fig. 1).

2.2.1 Sampling Locations

Three contiguous 50 m transects were set parallel to the shoreline at each of two depths in each of the study bays (Fig. 2). A depth of 7 m was selected as the primary sampling depth because of substrate characteristics and time/depth limitations for divers. Transect locations at 7 m depth were chosen in each bay using as criteria (1) similarity in substrate characteristics and infaunal community composition among transects and bays (as determined during preliminary surveys in August 1980 and, for Bay 7, 1981), and (2) facility of sampling (soft substrate with as little surface rock as possible). The second set of three transects in each bay was located immediately inshore of the 7 m transects at a depth of 3 m, where a relatively even cover of algae occurred in each bay.

Transect locations at 3 and 7 m depths in Bays 9-11 were marked underwater during Pre-spill Period 1 (September 1980) by driving steel rods approximately 1 m into the substrate at 50 m intervals along a 150 m line. In each bay, sighting lines at the ends of the transects were established on the shore by placing pairs of markers on the beach. Transects were located in subsequent periods using the surface and underwater markers.

A 150 m transect rope marked at 1 m intervals was set between the permanent stakes before (and removed after) sampling at each bay/depth/period combination in 1980 and 1981. Transect lines were left in place from August 1982 until August 1983. The 150 m transect rope marked the locations of three 50 m transects at each depth in each bay. Airlift sampling locations 1 m^2 in area, immediately seaward or shoreward of the line, were selected using a random numbers table, and the exact location of the 0.0625 m^2 sample within each of these 1 m^2 areas was selected to avoid large rocks on the surface of the sediment. Photograph locations along each transect were also randomly selected, and were indicated on a list attached to the camera. Sample locations for airlifts and photographs were re-randomized for each transect and period; on any given transect, randomly selected airlift locations were rejected if they had been used during a previous period. *In situ* counts and supporting collections were made within 1 x 10 m belts along each transect line.

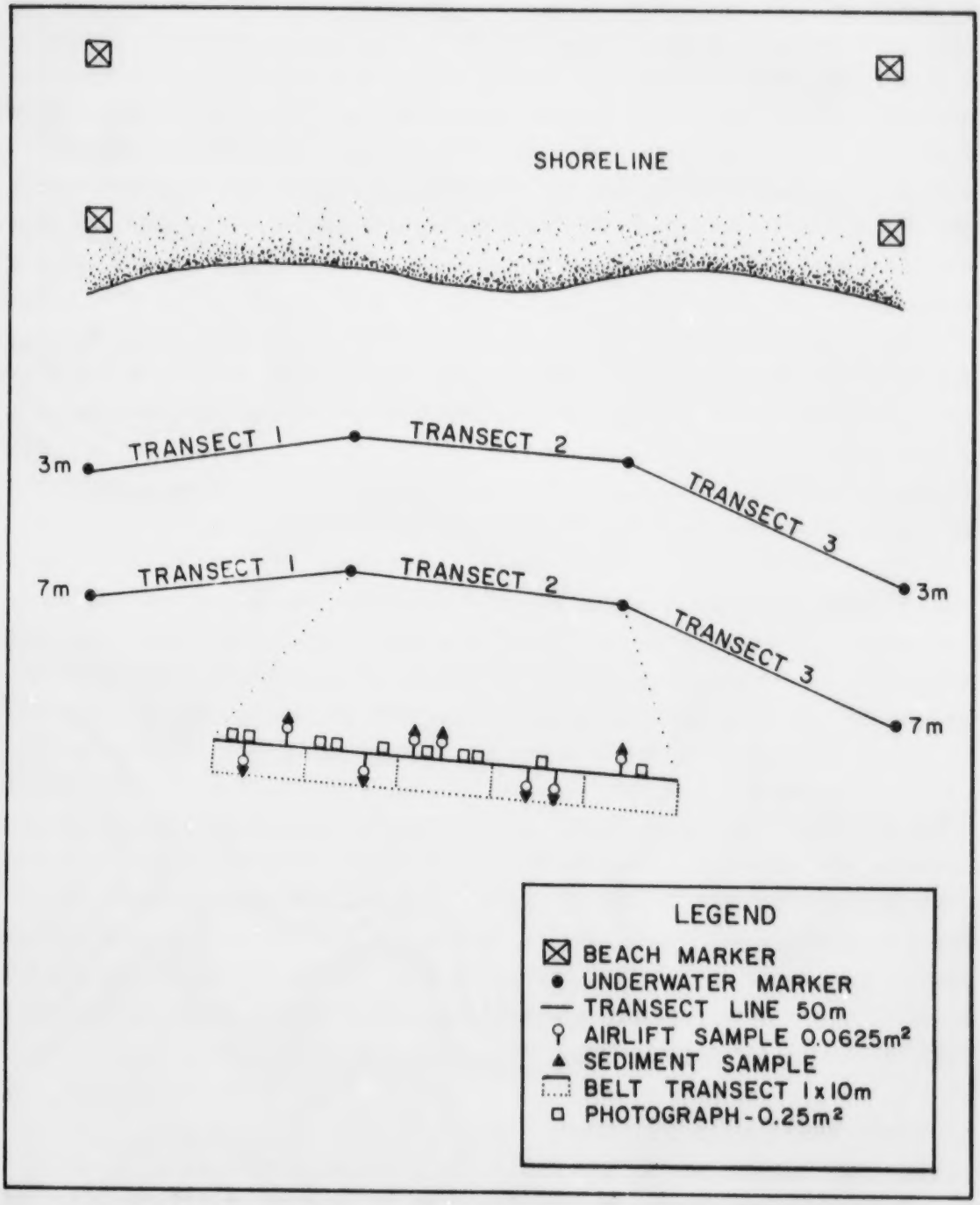


Figure 2. Schematic representation of sampling design for BIOS benthic study. Configuration of transects shown was repeated in each bay, and types and numbers of samples shown for one transect were repeated on each transect at each depth in each bay and period.

2.2.2 Airlift Sampling

Infauna were sampled by means of a self-contained diver-operated airlift. Eight replicate samples were obtained on each of three 50 m transects at each of two depths in each of three bays in September 1980 (total of 144 samples), in each of four bays in each of August and September in 1981 and 1982 (total of 384 samples in each year), and in each of four bays in August 1983 (192 samples).

The airlift consisted of a weighted 2 m length of pipe 8 cm in diameter fitted at the top with a 1 mm mesh net which retained the sample and could be removed quickly and capped. Air was supplied from a 20 MPa air cylinder fitted with the first stage of a diving regulator, which reduced air pressure to approximately 860 kPa above ambient. Areas to be sampled were demarcated by a ring containing an area of 0.0625 m^2.

The ring was placed on the bottom and pushed as far as possible into the substrate to contain shallow infauna. The airlift was inserted into the ring, the air was turned on, and the mouth of the airlift was moved around to thoroughly cover the area within the ring. The air was turned off when all visible organisms had been collected. The net on the airlift was then removed, capped and replaced, and the depth of penetration of the airlift into the substrate was measured to the nearest cm. A sample of surface sediment was collected in a polyethylene jar immediately beside the excavated area during September 1980 in Bays 9, 10 and 11, and during August 1981 in Bay 7. After three or four airlift samples had been taken they were raised to the boat and rinsed in the collecting bags from the side of the boat in order to remove fine sediments. Immediately after each dive all samples were returned to the field laboratory.

2.2.3 Quantitative Photography

A photographic record of each transect during each period was obtained on colour slide film using a Nikonos camera with a 15 mm lens, paired Vivitar electronic flashes, and a fixed-focus framer covering a bottom area of approximately 0.25 m^2. Ten photographs were taken at randomly located

intervals along each 50 m transect line during each period. In addition to providing a permanent visual record of each study area, photographs were used to estimate densities of visible surface fauna that were too sparsely distributed to be represented adequately in airlift samples. In order to obtain quantitative information on effects that were apparent immediately after the dispersed oil release, an additional six randomly located photographs were taken on each transect in Bays 9 and 10 on the second day following the release. Photographs were also taken in Bays 7 and 11 on the fourth and fifth days following the release. (No immediate effects were apparent in these bays.)

2.2.4 In Situ Counts

Macrophytes and those invertebrates too large and sparsely distributed to be sampled representatively by airlift or camera were counted *in situ*. On each 50 m transect during each period, counts of urchins, starfish and individual kelp plants were made within five 1 x 10 m strips parallel to and immediately adjacent to the transect line. Collections of representative plants and animals were also made for species identification. Additional counts of urchins and starfish were made after the dispersed oil release in 1981 using both *in situ* and photographic techniques (see above).

2.3 Laboratory Analysis Procedures

All samples were processed in the field within 12 h of collection. Samples were emptied into large plastic trays, and nets were carefully rinsed and picked clean. Entire samples (minus large rocks and gravel) were labelled and preserved in 10% formalin : 90% seawater. Macrophytic algae other than those in airlift samples were pressed on herbarium paper and dried at room temperature.

Detailed laboratory processing and analysis of the samples was carried out within six months of collection. All samples collected (1104) were analyzed except for (1) the 48 samples collected in Bay 10 during 1983, and (2) four samples that were inadvertently mixed during laboratory analysis in 1981. In one case, two samples from different depths (3 m and 7 m, Bay 10,

Pre-spill Period 2) were mixed; these were not analyzed. In two cases, two samples from the same transect were mixed: 3 m and 7 m in Bay 11 during Post-spill Period 1. In these two cases the two samples were combined, processed, and the results divided by two to provide data on one 'composite' sample. The resultant loss in data was, therefore, one of eight replicates at each of 3 m and 7 m in Bay 10 during Pre-spill Period 2, and at each of 3 m and 7 m in Bay 11 during Post-spill Period 1.

Samples initially were rinsed to remove formalin and sediment, and then were separated into five fractions. The first fraction, consisting of all material passing through a 1 mm mesh screen and retained on a 0.45 mm mesh screen, was preserved in alcohol for future reference. The second fraction, separated by rinsing, contained algae, detritus and most soft-bodied animals. This fraction was examined under a binocular microscope and animals $\geq$1 mm in length were sorted into major taxonomic groups; the remaining algae and detritus was blotted dry and weighed on a Mettler PT 200 balance. In 52 samples that contained large volumes of algae (>500 mL), large and conspicuous organisms were picked from the entire sample but only a subsample of known weight was examined microscopically.

Fractions three to five were obtained by using nested sieves to separate the balance of the sample into three different size fractions (1-2.8 mm; 2.8-5.6 mm; $\geq$5.6 mm) containing sand, gravel, bivalves and some soft-bodied animals. The large fraction was sorted in a glass tray into major taxonomic groups. Shell fragments and entire bivalve shells were separated, labelled and stored for future reference.

The 1-2.8 mm and 2.8-5.6 mm fractions from 1980 and 1981 samples were routinely sorted under a binocular microscope. Careful checking of a number of these samples indicated that approximately 10% of the smaller organisms remained in the sand and gravel, and were excluded from analysis. Hence a more efficient method using differential specific gravity (Sellmer 1956) was used in 1982 and 1983. During 1983, we also applied this improved method to sand and gravel from the 1980 and 1981 samples. The 1 mm and 2.8 mm sieves were placed on paper towelling to remove excess moisture, and the contents were then emptied into a plastic pail containing a 70% solution (by weight)

of $ZnCl_2$ (s.g. = 2.0). The mixture was gently stirred and organisms that floated to the surface were removed with a 1 mm mesh net. The procedure was repeated a minimum of two times. The specific gravity of the solution was measured before each sample was processed, and kept relatively constant (s.g. = 1.8-2.0) by adding $ZnCl_2$ as necessary. The combined net contents were sorted into major taxonomic groups, and entire bivalve shells were separated and stored in labelled plastic bags for future reference. The 1980-81 results in this report differ slightly from those in earlier reports because they now include animals isolated by the $ZnCl_2$ method. The 1980-1983 results in this report are directly comparable.

All animals were identified to species level whenever possible; unidentified or tentatively identified species were sent to appropriate authorities for identification or verification (see Acknowledgements). In cases where verifications indicated that additional taxonomic effort was required on previous years' samples, the taxa in question were re-examined during the final year (1983). In cases where it is generally recognized that additional species descriptions or revisions of higher taxonomic levels are required, questionable species or genera were pooled at the next highest taxonomic level prior to analysis. For each taxon identified, individuals were counted, gently blotted dry, and weighed together to the nearest milligram on a Mettler PT 200 or PC 220 balance. Unless otherwise specified (see below), all weights presented in this report are preserved (10% formalin) wet weights, including mollusc shells but excluding polychaete tubes. Lengths of individuals of all bivalve species, and diameters of the calcareous oral rings of the holothurian Myriotrochus rinkii, were measured to the nearest mm. After laboratory examination, all taxa were stored in 75% ethanol; a solution of 3% propylene glycol in 75% ethanol was used for crustaceans.

For each of four common bivalve species (Mya truncata, Astarte borealis, Macoma calcarea, and Serripes groenlandicus), the relationships between length, wet weight and dry weight were derived as follows: for each bay and period, approximately fifty undamaged individuals of each species were selected (where possible) from airlift samples taken along the middle transect at 7 m depth; S. groenlandicus was selected only from 1981, 1982 and

1983 samples. If necessary to obtain a sample size of 50 per bay, animals from the inner ends of the outer two 7 m transects were also used. For each individual the length, wet weight including shell, wet meat weight, and dry (constant) meat weight were determined. Constant dry weight was obtained by drying at 60°C in a Fisher Isotemp Oven Model 301 for 24 to 48 hours (depending on species), time periods which were established by weighing at daily intervals until constant weight was found.

Airlift samples of algae and detritus from 3 m depths were weighed (see below), and 524 of the 526 samples were analyzed in detail. Large and conspicuous species were sorted from each of these samples and weighed; in 33 cases (samples that had been subsampled for invertebrate sorting), only the subsample was examined. A subsample of approximately 2 g wet weight was separated from the balance of the sample, and sorted completely into the following categories: Stictyosiphon tortilis, Dictyosiphon foeniculaceus, Sphacelaria spp., a mixture of Pilayella littoralis and tubular diatoms, other species, and detritus (non-algal material). An appropriate subsample factor was then applied to extrapolate these results to the unsorted portion of the sample. Formalin wet weights were determined by rinsing in water, removing water by vacuum filtration in a Buchner funnel using Whatman #1 Qualitative filter paper until drops were 30 seconds apart, and weighing immediately to the nearest milligram on a Mettler PC 220 balance.

Methods used in sediment analysis were identical to those of McLaren et al. (1981). The sand fractions (<4.0 Φ) were separated using 0.5 Φ interval sieves in the range of -1.0 Φ to 4.0 Φ . Silt and clay (>4.0 Φ) were determined using the pipette method. Gravel content was determined for entire samples, but was excluded from all other calculations (grain size, sorting coefficient and percent composition of sand, silt and clay).

2.4 Data Processing and Analysis

All quantitative data collected in the field and all results from laboratory analyses were coded for computer processing. Sediment data were processed on an Apple II microcomputer; all other data were processed using an IBM 3033/N12 computer. Computer programs developed by LGL were used to generate the sample by sample, transect by transect, and bay by bay

tabulations that were used to select species and taxa for further analyses. Other LGL programs were used to organize the data into a format acceptable to packaged statistical programs. Prior to analyses, a logarithmic transformation (log [x+1]) was applied to density and biomass data in order to reduce the skewness inherent in such data.

Many of the analyses conducted on 1980 data (Cross and Thomson 1981) showed significant between-depth differences in the study bays. Furthermore, differences between depths were not consistent among bays (the bay x depth interaction term was significant). Inclusion of depth as a term in the overall analysis would have rendered interpretation difficult if not impossible. Depths were, therefore, treated separately in all types of analysis.

To determine which factors affected particular variables, three-factor (periods, bays and transects) fixed-effects analyses of variance, with transects nested within periods and bays, were performed by the GLM procedure of the SAS computer program package (Helwig and Council 1979; Freund and Littell 1981). Because of the nested design, the among-transects term rather than the residual error term was used to test the significance of main effects (periods, bays) and of the interaction between the main effects. When interaction terms involving transects were non-significant ($P>0.05$), they were pooled with the transect term before we tested for main effects. When interactions involving transects were significant ($P\leq 0.05$), they were not pooled with the transect term, which was used alone as the denominator in the tests.

The unbalanced design that resulted from the addition of the fourth bay in 1981 (Bay 7--reference) necessitated the use of two separate types of analysis of variance in the second and third years of the study. Also, samples from Bay 10 (dispersed oil contamination) collected in 1983 were not analyzed; hence a third analysis type was added in the present study. One analysis included data from the first five periods (1980-1982) but only the three bays sampled in all these periods (Bays 9, 10 and 11). The second analysis included data from all four bays but only the four periods during which all bays were sampled (1981 and 1982). The third analysis included

data from the last five periods (1981-1983) and the three bays sampled in each of these periods (Bays 7, 9 and 11).

Multivariate methods were used in order to examine the variability in the benthic community as a whole. Factor analysis (BMDP4M; Dixon and Brown 1981) was used to identify recurring groups of species and to reduce the number of variables in subsequent analyses. At each depth, species selected for analysis were those that accounted for 0.9% or more of density. The principal components method was used to extract initial factors from the correlation matrix of log-transformed species abundance data. Final factors were generated by varimax rotation. Separate factor analyses were performed for 3 and 7 m depths. At the 3 m depth, five factors with eigenvalues >1 were extracted. These accounted for 65.1% of the variance represented by the 21 species variables. At the 7 m depth, six factors with eigenvalues >1 were extracted; they accounted for 59.0% of the variance represented by the 23 species variables. The scoring coefficients produced by the two analyses were applied to log-transformed species abundances to produce factor scores for all samples collected during all sampling periods.

These factor scores were used as dependent variables in multivariate analyses of variance (SAS general linear models program; Helwig and Council 1979), using the three-way design (periods, bays, transects nested within bays and periods) employed in univariate analyses of variance. Transect effects were used to test main effects, as above. An *a priori* decision was made to use Pillai's trace as the test of significance in multivariate analyses of variance. As in the case of univariate analyses, three separate types of analysis were performed because of the lack of data from Bay 7 in the first sampling period and Bay 10 in the last period. In addition, a separate unbalanced multivariate analysis of variance (using data from all bays and periods) was run for each depth in order to produce vectors derived from consideration of all of the data. Elements of the vectors that were produced for each test of main effects and which accounted for more than 10% of variance were applied to the factor scores to derive discriminant functions.

To provide a graphic summary of the similarities and differences in the benthic communities in the various bays and periods, group centroids were plotted against the discriminant functions representing each test of main effects and interaction. Also, dendrograms were produced using a simple cluster analysis of mean factor scores for each bay x period combination (BMDP2M, Dixon and Brown 1981). This hierarchical agglomerative technique formed clusters on the basis of Euclidean distance between mean scores.

The functional relationships between lengths and weights of dominant bivalve species were identified by analysis of (1) scatter plots of the 1980 data, and (2) plots of residuals generated by regression analyses (Cross and Thomson 1981). The type of relationship determined the type of transformation used in subsequent analyses. Analyses of covariance with the corresponding function of length as the covariate were used to test for differences in dry meat weight among periods and bays, using data from all four years. Analyses of covariance were carried out using the SAS GLM procedure (Helwig and Council 1979). This procedure also produces adjusted mean weights for each of the bay/period combinations. These weights have been adjusted for among-bay and among-period differences in mean length; they represent mean weight at a standard length, and allow comparisons of relative weights of bivalves among bays and periods. These means were produced in an analysis that considered all of the bays and periods for which data were available.

The mean lengths of selected bivalve species were calculated for each sample and analyses of variance were used to test whether mean lengths of these species differed among bays or periods.

SECTION THREE

RESULTS AND DISCUSSION

The benthos in the study bays at Cape Hatt consists of a wide variety of plants and animals. For the purposes of the present study, the animals have been classified into two groups according to their relative mobility. The term infauna will be used to refer to those animals that are either incapable of motion or are able to move only slowly in the sediment or on the sediment surface. This group includes bivalves, polychaetes, gastropods, priapulids, nemerteans and some echinoderms. The term epibenthos will be used for those animals capable of relatively rapid motion, including amphipods, cumaceans and ostracods, and large echinoderms capable of moving relatively large distances on the sediment surface (urchins and starfish). Both of these groups (infauna and epibenthos) are included in the infauna as defined by Thorson (1957).

The infauna and epibenthos (as defined above) are treated separately in the present study. Most analyses and discussion concern infauna, primarily because their relative immobility exposes them to the full impact of oil or dispersed oil and facilitates the interpretation of results. With mobile epibenthos, it is often impossible to distinguish between mortality and emigration as the cause of disappearance following an oilspill (e.g. Elmgren et al. 1980). Infauna are also of interest because of their dominance of total benthic biomass (in the study bays at Cape Hatt, 46.4% of total biomass and 98.4% of total faunal biomass at 3 m depth, and 96.1% of total faunal biomass at 7 m depth), and because of their long life spans in the Arctic (Curtis 1977; Petersen 1978). The latter further facilitates interpretation of results because it is indicative of comparatively reduced seasonal and annual variability.

3.1 Evaluation of Methods

3.1.1 Study Design

The design of this study incorporates several potential sources of variability besides any effects of oil or dispersed oil. These include water depth, spatial variability on three scales (within transects, among transects within bays, among bays), and temporal variability between seasons and years. It is important to examine the effects of each of these sources of potential variability in order to differentiate their effects from those of oil or dispersed oil.

The effect of depth (3 m *vs.* 7 m) was assessed in the first year of studies (Cross and Thomson 1981). Significant between-depth differences in infaunal communities were found. Furthermore, these differences between depths were not consistent among the three bays studied. The latter effect (an interaction effect in statistical terms) was itself indicative of a depth effect, but for statistical reasons the significant interaction precluded unambiguous interpretation of depth or bay effects in an overall analysis considering both depths. The addition of a temporal effect after the second year of studies increased the number of possible interactions involving depth (depth x bay; depth x period; depth x period x bay), thereby rendering interpretation of any effect practically impossible. Thus, separate analyses are used for data from each depth throughout the present report, thereby eliminating the depth term and all interaction terms involving depth from the analyses.

Spatial and temporal variability are fundamental to the study design. The smallest-scale variability, that among replicate samples within transects, is used as a basis of comparison for variation among transects. Among-transect variation, in turn, is used to determine the significance of variation among bays. This among-bay variation is one of the main effects we are testing; differences among bays, however, could be attributable either to natural factors or to the different oil treatments applied in the different bays. An additional factor (time) is required in order to differentiate between oil effects and natural spatial variability. The temporal

variability assessed in the BIOS project, termed the period effect, includes both seasonal and year-to-year components. Sampling was carried out in both August and September, and in different years.

Thus for data from each depth, analyses of variance included three factors: transects (nested within bays), bays and periods. These factors had three, four and six levels, respectively. However, the design of the experiment is unbalanced because there are no data from one of the bays (Bay 7--reference) in the first pre-spill sampling period (September 1980) or from another bay (Bay 10--dispersed oil contamination) in the last post-spill sampling period (August 1982). The unbalanced design necessitated the use of three different analysis types (see Section 2.4), as results of a single analysis with two missing cells would have been ambiguous. Interpretation of the results of these tests was difficult in cases where the results of the three analysis types (involving different combinations of bays and periods) were inconsistent.

To determine whether oil had an effect, we compared (1) temporal changes in the experimental (oil release) bays with temporal changes in the reference bay, and (2) temporal changes in the surface oil release bay with those in the dispersed oil bays. These comparisons are based on sampling periods ranging from one year pre-spill to two years post-spill. In statistical terms, a significant interaction between bay and period effects indicates a possible oil effect. For variables (e.g., species) where the bay x period interaction was significant, the probable source of the interaction was located through (1) comparison of the results of the three analysis types, (2) inspection of the log-transformed data, and (3) additional analyses of variance. The probable source (i.e. the particular bay(s) where temporal change was not consistent) was then compared with the oil treatment regime in order to determine whether there was an effect of oil.

There exists the possibility of committing two types of errors in these tests. A type I error would cause rejection of the null (no effect) hypothesis when it was true (finding apparent effects when there were none). A type II error would cause acceptance of the null hypothesis when it was in fact false (not detecting effects that did occur).

Type I errors are of concern because of the large number of statistical analyses carried out. Decisions to accept or reject the null hypothesis were based on a probability level of 0.05. When a test indicates that the effect is significant, it is actually indicating that there is less than a 1 in 20 chance that differences as large as those observed could occur as a result of chance sampling effects if there were no real differences. However, a total of 371 period x bay interaction tests were performed on the data. Hence we would expect that approximately 19 type I errors would be made if there were no real differences. In fact, a total of 33 significant interactions were found in the 371 tests. This is not many more than the 19 expected by chance. However, the nature of each significant interaction was examined and discussed in consideration of the type of oil treatment (surface vs. dispersed) and the concentrations of oil, both in the water during and immediately after the oil releases, and in the subtidal sediments during 1981 to 1983. Inspection of the nature of the 33 seemingly significant interactions showed that 11 were consistent with a possible oil effect. We can be reasonably confident that these 11 significant interactions are indicative of real oil effects.

Occurrence of type II errors in the analyses (i.e. not detecting effects that did occur) should have been minimized by the use of spatial and temporal controls, and the large number of samples analyzed (1052 samples of infauna and epibenthos, 524 samples of algae, 405 *in situ* counts). Temporal controls were established by sampling in September 1980 and in August 1981 prior to the experimental oil releases. Pre-spill sampling for petroleum hydrocarbons confirmed that the study bays were uncontaminated at that time (Boehm 1981). The spatial control (Bay 7) was contaminated during the dispersed oil release, but because the level of contamination was very low (see Section 3.3), Bay 7 was maintained as a 'reference' bay.

The nested analysis design used in the present study produces a conservative test for oil effects. Changes caused by introduction of oil must be greater than natural variability among 50 m transects in order to be detected. This is a reasonable approach in a study of an inherently variable system. However, it is possible that oil effects were present but were not detected by the conservative test.

3.1.2 Sampling Efficiency

It is of particular importance in a structured study such as this to ensure that the community studied is representatively sampled, i.e. to collect an adequate number of samples of a size appropriate to the organisms' distributions, and to collect all organisms of a specified minimum size within the sampling unit. Clearly, it is desirable to collect a large number of samples and to use a small mesh size in sample collection and processing, but there are always logistic constraints to consider (Green 1979). The sampling design in the present study was in general decided *a priori*, whereas some of the options (e.g., mesh size and therefore minimum organism size; sample unit area; matched *vs*. re-randomized sampling in different periods) were evaluated during preliminary sampling in 1980. In the present section, we discuss the above considerations and present data in order to evaluate sampling efficiency and point out possible sources of error in the present study.

Mesh size of sampling and sample processing equipment determines the minimum size of organisms that are quantitatively sampled, although some individuals smaller than the mesh size are retained. Birkett and McIntyre (1971) suggested that a 0.5 mm mesh size should be used for macrofauna, but pointed out that in coarse sediments this size may retain too much material. Elsewhere, 1 mm has been used as the minimum mesh (and organism) size for macrofauna (e.g., Ankar and Elmgren 1978). During preliminary sampling at Cape Hatt in 1980, we found that the use of a 0.5 mm mesh collecting bag increased the amount of sand collected by about 5 x over that retained in a 1 mm mesh bag. Because 0.5 mm mesh would have greatly increased sample collection and processing time, we have used 1 mm as the lower limit.

Penetration depth of sampling devices is of particular concern where deeply burrowing animals occur, and the inadequacy of most grab samples in this respect is well known (e.g., Holme 1971; McIntyre 1971). The problem is particularly acute when the substrate consists of hard-packed sand or sediments with high gravel or rock content. The latter type of substrate occurs in each of the study bays at Cape Hatt, and an airlift sampler was chosen for this reason. Preliminary sampling in August 1980 indicated that

all of the species and most of the individuals found in the Cape Hatt benthic community could be sampled adequately with a sampler penetration depth of no more than 8 to 10 cm. However, a large proportion of the benthic biomass was contributed by large individuals of the bivalve Mya truncata, which occurred to depths of 15 cm in the sediment.

Mean depth of penetration of the airlift sampler used in the present study was from 12.0 to 17.1 cm at 7 m depth in each of the bays and periods (Table 1). Analysis of variance indicated that penetration depth on 7 m transects did not vary significantly among bays or periods, nor was there any significant bay x period interaction (Appendix B). Furthermore, visual and tactile inspection of sampling plots by divers during and after sampling ensured that all large individuals of Mya truncata were collected by the sampler. Sampler penetration was shallower at 3 m depth in all bays (6.0 to 14.6 cm; Table 2) due to the presence of a consolidated impenetrable sediment layer and/or rock. At this depth, bay and period differences were ambiguous in two types of analysis of variance (Appendix B) because of significant ($P>0.01$) interactions between bay and period factors. In the third analysis type, period and bay differences were significant (Table 2). Again, however; inspection of the sampling plots ensured that all large individuals of M. truncata were collected.

The available data on highly motile epibenthic crustaceans at Cape Hatt were from the same airlift samples upon which infaunal results were based. Estimates for epibenthic crustaceans likely are not as accurate as those for infauna, however, because of escape of organisms from the area sampled and inclusion of those inadvertently drawn into the airlift from outside the 0.0625 m^2 sampling areas. A modification to the sampler, developed for EAMES studies to overcome this shortcoming (see Thomson and Cross 1980), was not practical in the present study because of difficulties in operating the airlift in the mixed sediment-rock substrate. No quantitative estimates are available for the extent to which epibenthic crustaceans were over- or under-estimated in the present study. However, there is no reason to expect differences among bays or periods in the accuracy of our estimates, so conclusions about oil effects are not affected.

Table 1. Penetration depths (cm) of the airlift samples in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Data are expressed as mean ± standard deviation and are based on eight replicate 0.0625 m^2 samples on each of three transects for each depth, period and bay.

Depth	Period	Bay 7	Bay 9	Bay 10	Bay 11
3 m	Pre-spill 1	-	10.7 ± 2.7	11.2 ± 2.7	8.0 ± 2.8
	Pre-spill 2	7.6 ± 2.5	10.5 ± 3.3	10.3 ± 2.4	10.4 ± 3.9
	Post-spill 1	8.1 ± 2.8	14.6 ± 3.7	11.4 ± 3.2	11.7 ± 4.2
	Post-spill 2	6.0 ± 3.1	14.1 ± 3.3	11.5 ± 3.7	9.3 ± 4.6
	Post-spill 3	7.3 ± 2.3	11.4 ± 3.9	13.3 ± 3.0	10.0 ± 5.3
	Post-spill 4	8.7 ± 1.7	12.9 ± 4.2	-	12.5 ± 4.1
7 m	Pre-spill 1	-	16.4 ± 2.7	15.8 ± 3.7	16.9 ± 3.0
	Pre-spill 2	12.0 ± 2.8	13.0 ± 3.3	14.5 ± 3.4	12.9 ± 2.2
	Post-spill 1	13.6 ± 2.7	15.9 ± 2.7	14.7 ± 2.4	17.1 ± 6.2
	Post-spill 2	15.0 ± 3.4	14.6 ± 2.9	13.5 ± 2.8	14.3 ± 2.9
	Post-spill 3	13.0 ± 3.4	12.9 ± 4.5	15.3 ± 4.5	14.3 ± 4.2
	Post-spill	15.5 ± 3.7	14.9 ± 2.5	-	14.5 ± 3.0

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

The **area of the sampling unit** employed in the present study (0.0625 m^2) was somewhat smaller than the 0.1 m^2 area that is generally recommended (e.g., McIntyre 1971), although this recommendation is based primarily on the performance of grab samplers. The size of our sampler appears to be adequate, however, based on Green's (1979; p. 38) rule of thumb that the ratio of the volume of the organism to the volume of the sample unit should be 0.05 or less. The largest organism in our samples, Mya truncata, was at most about 50 cc in volume, whereas the volume sampled was approximately 10 L (ratio of 0.005). Furthermore, our samples contained an average of more than 200 infaunal individuals per sample; those species included in analyses of community structure (those contributing 0.9% or more to total numbers), therefore, averaged about two individuals per sample. The epibenthic taxa considered for analysis were less abundant, but the least abundant taxon considered at each depth still averaged about one individual per sample. Animals more sparsely distributed, including many small species and some large species (e.g., the bivalve Clinocardium ciliatum, the gastropod genus Buccinum, the polychaete genus Phyllodoce and the decapod Sclerocrangon boreas), were excluded from analysis.

The **number of replicate samples** collected (8 per transect and 24 per bay during each period), in conjunction with the size of the sampling unit, appears to have been adequate to obtain a representative sample of the communities present. Species-area curves are useful in determining the area that must be sampled in order to yield a representative estimate of the number of species present. The curves in Figure 3 show the cumulative number of species of infauna and of epibenthos collected in various numbers of samples at each depth in each bay. At both depths the curves flattened after 0.5 to 1.0 m^2 of substrate had been sampled (i.e. 8 to 16 samples). Depending on depth and bay, the number of infaunal species found in eight samples represented 73 to 85% of the total number of species collected in all 24 samples; 90 to 95% were found in 16 samples (1 m^2). The corresponding percentages for epibenthos were 78 to 96% in eight samples, and 89 to 100% in 16 samples.

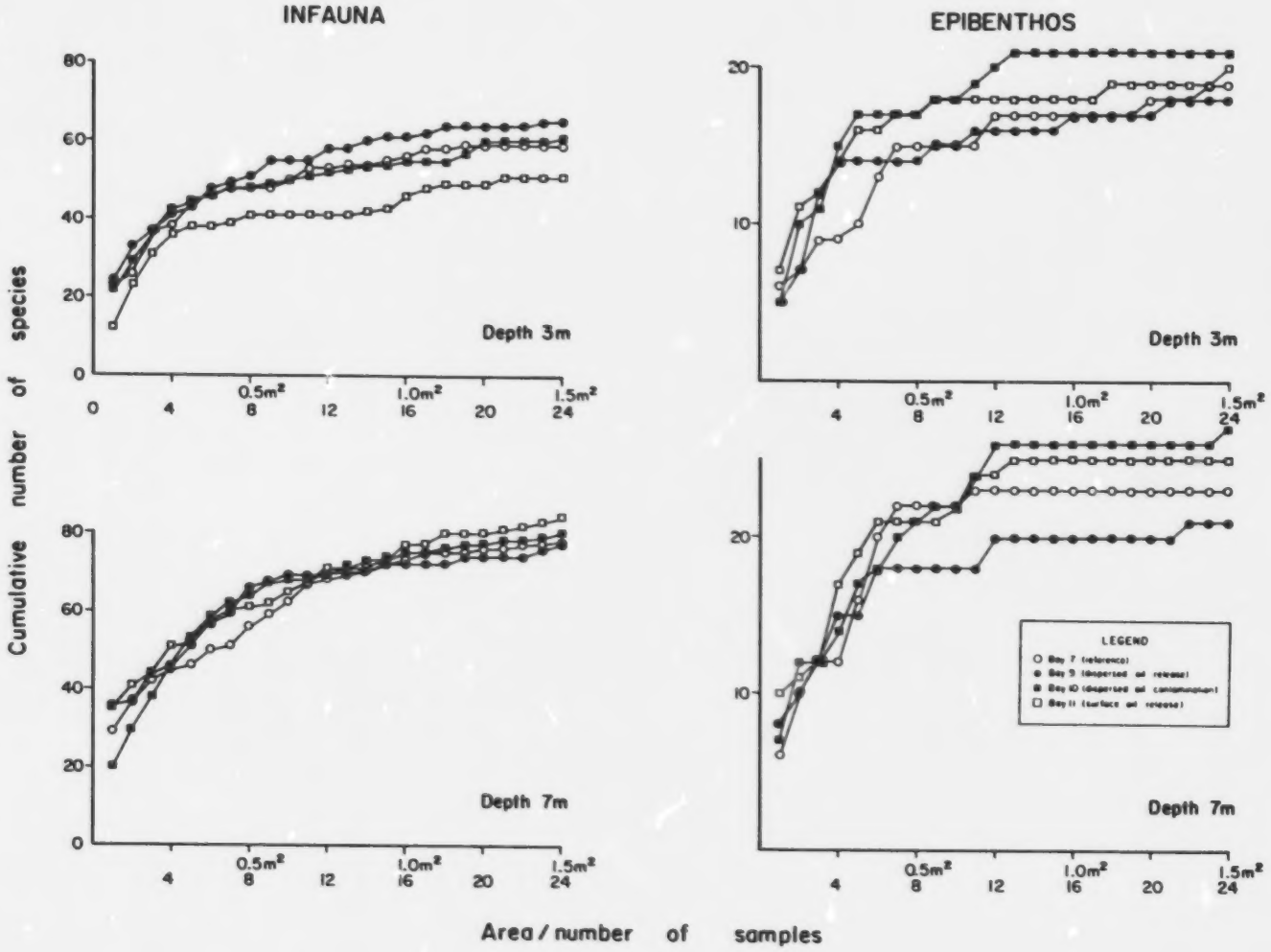


Figure 3. Species-area curves for infauna and epibenthos in four bays at Cape Hatt, northern Baffin Island, during September 1980 (Bays 9, 10 and 11) and during August 1981 (Bay 7).

Sampling locations 1 m^2 in area were selected along the transect lines using random numbers, but the exact location of the sample within the 1 m^2 area was selected to avoid large rocks on the substrate surface. Also, we did not sample in areas where there was evidence of recent ice scour. Thus our samples are biased toward areas of higher faunal abundance, and to some extent our data overestimate the actual abundance and biomass of benthos in the study bays. However, this bias was consistent in all bays and periods, and does not affect conclusions about oil effects.

One possible source of sampling error resulted from the loss, and subsequent replacement, of one of four transect markers at 3 m depth in each of Bays 9 and 10 in August 1981. The same marker was also lost and replaced in Bay 10 in August 1982. It is possible, therefore, that transect locations in these cases were not identical from year to year; hence, confounding of temporal and spatial variability may have occurred. However, these few transect markers were replaced as close to the original locations as possible by measuring depth, so their locations likely do not differ greatly from year to year. There were no obvious trends in the data for several species of infauna and macroalgae (i.e. no apparent transect x period interactions in Bays 9 and 10 between the appropriate sampling periods) to indicate that locations had differed greatly.

3.1.3 Laboratory Techniques

3.1.3.a Sample Sorting and Species Identification

Samples were analyzed in random order during all years to ensure that no among-bay or among-period bias occurred. Possible sources of error for which bias was avoided were progressive changes in procedure or operator error over the 2-4 month periods of laboratory analysis and, more importantly, in biomass of benthic plants and animals. Mills et al. (1982) have shown that bivalves lose weight in 10% formalin, and that all taxa tested lose weight in alcohol. Relative stability in weights was reached after one or two months in preservative. There may be some year-to-year variability in our biomass data, as laboratory analysis was completed about one month earlier in 1980 (September samples only) and two months earlier in 1983 (August samples only)

than in 1981 and 1982 (August and September samples). This variability is likely small, however, as all samples had been preserved for at least one month before wet weights were determined. Mills et al. (1982) concluded that "Precision, though not accuracy, of wet weights can only be achieved after specimens have been in preservation for a month or more".

The use of differential specific gravity (using $ZnCl_2$; Sellmer 1956) increased accuracy (by at least 10%) and precision in separating animals from the substrate; this procedure eliminated human error in sample sorting. This technique was used in 1982 and 1983, and, in 1983, was applied to 1980 and 1981 samples (the sand and gravel had been retained). The 1980-1983 results in this report are now directly comparable, and supersede all previously reported results.

Year-to-year consistency in species identification was ensured in 1983. The results of verifications of species identifications were incorporated, and samples from previous years were re-analyzed where necessary. Furthermore, all bivalve samples were re-analysed in 1983 to correct any inconsistencies among years that resulted from analysis by different technicians in different years. All other major groups (polychaetes, gastropods, echinoderms and amphipods) were identified by permanent staff.

3.1.3.b Weight-Length Relationships

Dry weights of bivalves used in weight-length analyses were based on specimens initially preserved in 10% formalin, and transferred to 75% alcohol after samples were sorted. Thus, the dry weights reported in this report underestimate actual dry weight. Length of time in each preservative varied among samples, but samples were analyzed in random order to eliminate bias among bays and periods. Bias was introduced in 1983, however, when dry weight determinations were carried out 2-3 months earlier than in previous years. The effect of increased time in alcohol (10 *vs.* 125 days) was, therefore, tested for *Macoma calcarea* from one bay (Bay 7). Analysis of covariance showed a highly significant difference in regression line slopes for samples of 50 individuals that were in 75% alcohol for 10 and 125 d ($F = 13.88$; $df = 1,96$; $P = 0.0003$). After preservation for 125 d, the

mean dry weight of an average-sized Macoma was 87.8% of the mean after 10 d. This bias is considered further in Section 3.4.5.

3.2 Subtidal Sediments

Information on the nearshore geology of the study area was reported by McLaren et al. (1981). In the present section we briefly describe substrates in the study bays, and present sediment data based on samples taken in conjunction with airlift sampling on 3 and 7 m transects.

The four study bays were generally similar in substrate characteristics. The beaches and intertidal zones were composed of a gravel/cobble pavement overlying sand with scattered rocks and boulders. At depths of 1-2 m, a relatively flat, predominantly sand bottom occurred in each of the study bays, and between 2 and 3 m depths a steep, rocky slope occurred in each of the shallow embayments in Ragged Channel (Bays 7, 9 and 10). The 3 m transect lines were just seaward of this slope. The substrate on 3 and 7 m transects consisted of a mixture of silt, sand, gravel and larger rocks. With increasing depth, an unconsolidated silt veneer overlying the substrate became more predominant, and sparsely distributed boulders occurred.

Grain size data (Table 2) are expressed in logarithmic Φ units. Large numbers mean fine grain. Gravel consists of particles greater than 2 mm across, and for present purposes is excluded from all calculations except where % gravel is discussed. Sand falls in the range of -1.0 Φ (2 mm) to 4.0 Φ (0.0605 mm), silt in the range of 4.0 Φ to 9.0 Φ (0.002 mm), and clay is finer than 9.0 Φ.

Sediments at 3 m depth were generally fine to very fine sand (2-4 Φ). In all but four samples, sand comprised at least 75% of the fines fraction of the substrate. The clay content was generally less than 5%. Sediment differences among bays were small, as was within-bay variability in mean grain size, sorting coefficient, and percent sand, silt and clay (Table 2). Percent gravel was considerably more variable within bays, and a much higher gravel content occurred in Bay 7 than in the other three bays.

Table 2. Sediment characteristics at two depths in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and August 1981[2]. Data are expressed as mean ± standard deviation.

Depth	Bay	Mean grain size (Φ)	Sorting (Φ)	Gravel[3] (%)	Sand (%)	Silt (%)	Clay (%)	Sample size
3 m	7	2.66 ± 0.53	2.40 ± 0.30	76.15 ± 14.76	81.45 ± 7.84	15.53 ± 6.45	3.03 ± 1.58	23
	9	3.10 ± 0.30	2.29 ± 0.44	42.88 ± 22.00	83.27 ± 5.45	12.10 ± 4.29	4.63 ± 1.21	24
	10	3.34 ± 0.38	2.33 ± 0.28	33.73 ± 17.45	77.27 ± 7.77	17.61 ± 5.96	5.12 ± 1.95	24
	11	2.84 ± 0.24	2.35 ± 0.33	37.88 ± 16.95	82.95 ± 3.99	12.84 ± 3.10	4.21 ± 1.12	24
	All	3.00 ± 0.46	2.34 ± 0.34	47.36 ± 24.34	81.23 ± 6.79	14.51 ± 5.49	4.26 ± 1.67	95
7 m	7	4.09 ± 0.68	2.70 ± 0.28	66.96 ± 11.65	60.94 ± 13.19	32.14 ± 10.86	6.92 ± 3.19	24
	9	3.50 ± 0.17	2.14 ± 0.10	7.59 ± 5.25	80.54 ± 3.00	14.28 ± 2.46	5.18 ± 0.67	10
	10	3.78 ± 0.30	2.28 ± 0.16	18.41 ± 17.46	69.34 ± 6.88	24.96 ± 5.95	5.70 ± 1.08	14
	11	3.76 ± 0.51	3.18 ± 0.26	19.94 ± 11.05	65.56 ± 7.14	23.75 ± 4.60	10.67 ± 2.92	21
	All	3.84 ± 0.54	2.68 ± 0.45	34.20 ± 27.27	66.90 ± 11.21	25.54 ± 9.42	7.56 ± 3.30	69

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination) and Bay 11 (surface oil release).
[2] Pre-spill Period 1 (September 1980) for Bays 9, 10 and 11; Pre-spill Period 2 (August 1981) for Bay 7.
[3] Gravel is expressed as % of entire sample and excluded from all other calculations.

At 7 m depth, sediments were slightly finer (higher mean Φ) and more poorly sorted than at 3 m depth. The percentages of sand and gravel were lower, and percentages of silt and clay were higher than at 3 m (Table 2). As was the case at 3 m depth, among-bay differences in mean grain size and sorting coefficient were small at 7 m, and most sediment characteristics differed little within bays. Sediments had a lower percentage of gravel and silt and a higher content of sand in Bay 9 than in the other bays. The converse was true for each of these characteristics in Bay 7. Clay content in Bay 11 was considerably higher than in the other three bays.

3.3 Levels of Oil Contamination

Four bays at Cape Hatt, northern Baffin Island, were selected as experimental bays; oil was released on the surface of Bay 11, dispersed oil was released in the water column of Bay 9 and also contaminated Bay 10, and Bay 7 was used as a reference bay.

On 19 August 1981, 75 drums (15 m^3) of slightly aged Lagomedio crude oil were released on the surface in Bay 11. Approximately half of this amount was recovered on the day following the release. During the 6 h release and during the 30 h monitoring period that followed, oil concentrations in the top metre of water were low (<3 ppm) and concentrations below a depth of 1 m were below the detection limit of 0.25 ppm (Green et al. 1982). When oil levels in the water of Bay 11 were integrated over time, the total oil exposure was 1.2-2.1 ppm-h (Green et al. 1982). Approximately one third of the oil was deposited on the beach during the falling tide, and concentrations in the intertidal area reached 36,000 ppm (Green et al. 1982). This oil did not immediately become incorporated into Bay 11 sediments at 3 and 7 m depths (Boehm et al. 1982), but oil concentrations began to rise a few weeks following the release and were still rising 1 and 2 years thereafter. Mean oil concentrations in the sediment after one year were 7-9 ppm (Fig. 4; Boehm 1983), and after two years were 16 to 46 ppm (Fig. 4; Boehm et al. 1984). During both years the distribution of oil was patchy, and highest concentrations were found at the southern end of the study area (up to 150 ppm in 1983). Oil was largely confined to the upper 2 cm of sediment throughout the study period.

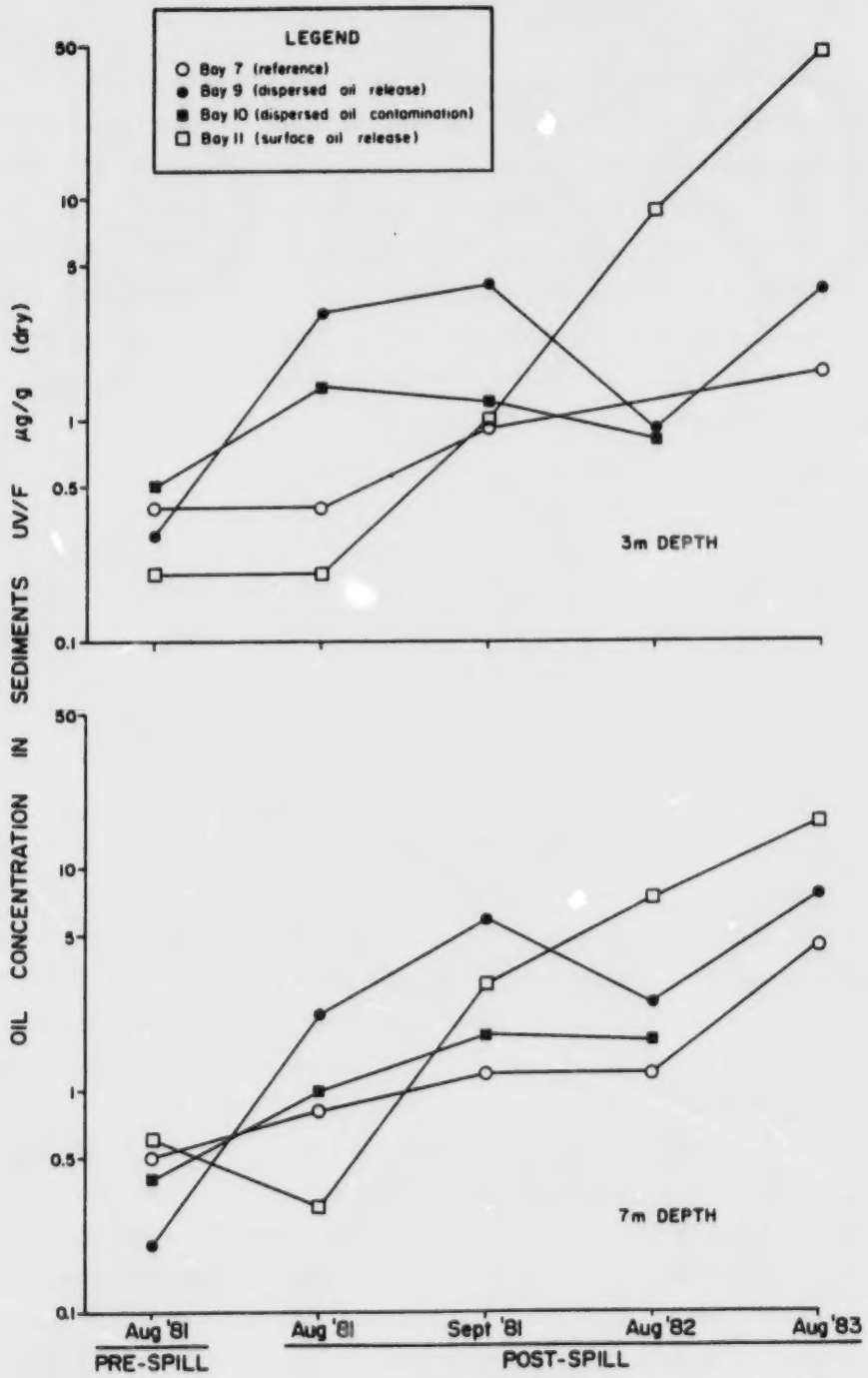


Figure 4. Mean oil concentrations (UV/F) in sediments from four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in August 1981, and during post-spill sampling in August and September 1981 and August 1982 and 1983. Values shown are means of all samples taken on benthic transects and tissue plots for the indicated depth, bay and period. The first post-spill sampling in Bay 11 occurred before the dispersed oil release. Mean concentration at 7 m depth in Bay 7 during August 1983 is a result of one high value (12.8 ug/g) containing petroleum; at 3 m depth, oil was not petrogenic. Data shown are from Boehm et al. (1982), Boehm (1983) and Boehm et al. (1984).

On 27 August 1981, an additional 15 m^3 of aged Lagomedio crude oil mixed with 1.5 m^3 of Corexit 9527 dispersant and with seawater (5:1, water:oil) were introduced into Bay 9 from a diffuser pipe that was about 1 m from the bottom and extended from the shore to a depth of 14 m. The movement of the released oil was stratified by depth. Surface (0-7 m) oil first circulated to the south and subsequently reached the sampling areas in Bay 9 some 6 h later, while the deep layer (7-15 m) moved north with the current directly into the experimental bay. Concentrations in the water column were high (~50 ppm) following the release. Horizontal diffusion was rapid, and after four days the dispersed oil was found throughout Ragged Channel at concentrations of 30-50 ppb. Total exposure to dispersed oil (based on 36 h observation) was 300 $\pm$ 100 ppm-h in Bay 9, approximately 30 ppm-h in Bay 10, and 0.5 ppm-h in Bays 7 and 11 (Green et al. 1982). Oil was still detectable in the water of the study bays (generally less than 5 ppb) more than two weeks after the dispersed oil release (Boehm et al. 1982, Tables 3.4 to 3.7).

Oil was quickly incorporated into the sediments in Bay 9 and, to a lesser degree, in Bays 7 and 10 (Fig. 4; Boehm et al. 1982). Concentrations in Bay 9 sediments reached a maximum of 4-6 ppm a few weeks (or later) following the release and were considerably lower one year later (Fig. 4). Low concentrations apparently persisted in Bay 7 and 10 sediments through 1982 (0.8 to 1.2 ppm). In the second post-spill year, however, oil concentrations had increased considerably in sediments of Bay 9 (averages of 3.8 and 7.7 ppm at 3 and 7 m depths, respectively). This oil may have been transported into the study area from the southern part of the bay where the dispersed oil was released in 1981. Levels had also increased somewhat in sediments of Bay 7, although oil in 3 m sediments was not petrogenic, and only one of five samples from 7 m depth contained a high concentration of petroleum (see Fig. 4; Boehm et al. 1984).

The oil levels in the sediment at Cape Hatt are relatively low (< 10 ppm on a dry sediment weight basis, with the exception of concentrations in Bay 11 during 1983) when compared with values reported in the literature. Following an oil spill in Chedabucto Bay, N.S., Scarratt and Zitco (1972) reported that sediment hydrocarbon concentrations (based on wet sediment weight) were 10-20 ppm at lightly oiled stations, and 160-1240 ppm at heavily oiled stations. Sanders et al. (1980) found 10-20 ppm hydrocarbon content

(based on dry sediment weight) in lightly oiled stations, and 1300-12,400 ppm (dry sediment) in heavily oiled stations after an oil spill in Buzzards Bay, Mass. Chronically oiled areas can contain similar sediment hydrocarbon concentrations: 4-60 ppm in lightly oiled areas and 820-6000 ppm in heavily oiled areas (Farrington and Quinn 1973; Koons and Thomas 1979; both based on dry sediment weight).

3.4 Infauna

3.4.1 Biomass

Overall average biomass in the study area at Cape Hatt (all bays and sampling periods combined) was 397.5 and 1407.1 g/m^2 at 3 and 7 m depths, respectively. These values are considerably higher than mean depth-integrated (5 to 50 m) biomass reported in other arctic areas:

Location*	Sample size	Mean biomass (g/m^2)	Source
Alaskan Beaufort Sea	131	41	Carey (1977)
Bridport Inlet, Melville Is.	78	94	Buchanan et al. (1977)
Brentford Bay, Boothia Pen.	21	188	Thomson et al. (1978)
Lancaster Sound	110	319	Thomson and Cross (1980)
Pond Inlet and Arctic Bay	51	200-438	Ellis (1960)

* Relatively high biomass (up to 1482 g/m^2 at one location, n = 7) has also been reported in West Greenland (Vibe 1939).

The apparently high infaunal biomass at Cape Hatt relative to that in other arctic locations is at least in part attributable to the effectiveness of our sampler. About half of the biomass found at 7 m depth at Cape Hatt represented the bivalve Mya truncata. Cross and Thomson (1981) found that this deeply burrowing species was only sampled effectively if the sediment was excavated to a depth of 15 cm. Buchanan et al. (1977) compared results of quantitative underwater photographs with those of shallow penetrating samplers and found that their shallow samples underestimated infaunal biomass by as much as 960 g/m^2. Many of the other low values previously reported may also be biased by inadequate sampling.

In most high arctic areas a barren zone extends from the shoreline to depths of 2-10 m. This zone is devoid of infauna except for the tunicate Rhizomolgula globularis, and is populated almost exclusively by motile amphipods. At Cape Hatt, however, a relatively high infaunal biomass consisting mainly of bivalves was found at 3 m depth. Here and elsewhere in Eclipse Sound the barren zone occurs only at shallower depths, likely due to the relatively protected location (Thomson and Cross 1980).

3.4.2 Group and Species Composition

Group composition of the infauna collected at each of 3 and 7 m depths in the study bays at Cape Hatt (bays and periods combined) is shown in Table 3. At both depths, bivalves accounted for most of the biomass--88.1 and 94.5% at 3 and 7 m depths, respectively. Mollusc wet weights in the present study include shell weight. The dominance of infaunal biomass by bivalves is reduced to approximately 75% and 85% at 3 and 7 m depths, respectively, when only tissue weight is considered (LGL Ltd., unpubl. data). Numbers of infauna were dominated by polychaetes at 3 m depth and by bivalves at 7 m depth; together these two groups accounted for approximately 80 to 90% of infaunal animals collected (Table 3).

The ten most common taxa at each depth at Cape Hatt, in terms of numbers and biomass, are shown in Table 4, and a complete species list is included in Appendix C. The ten dominant species accounted for more than 60% of numbers and 90% of the biomass of infauna at both depths. The four lists of ten species include 11 bivalves, six polychaetes, two gastropods and one holothurian (Table 4). Relatively few species were dominant (i.e. among the top 10 species) in terms of both density and biomass: the bivalves Mya truncata and Astarte borealis (both depths), the holothurian Myriotrochus rinkii (3 m depth only), and the polychaete Pectinaria (= Cistenides) granulata and the bivalves Astarte montagui, Macoma calcarea and Nuculana minuta (7 m depth only). The contributions of Astarte spp. and M. calcarea to density, and to a much lesser extent to biomass, are underestimated in Table 4 because unidentified juveniles of these two genera are not included (Astarte--3.12 and 4.30% of numbers at 3 and 7 m depths, respectively; Macoma--2.64% of numbers at 7 m depth).

Table 3. Group composition of infauna collected in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Based on 526 airlift samples, each covering 0.0625 m^2, at each of 3 and 7 m depths.

Taxon	% of total infaunal numbers		% of total infaunal biomass	
	3 m	7 m	3 m	7 m
Bivalvia	21.77	54.22	88.13	94.47
Polychaeta	57.41	35.64	7.12	2.94
Gastropoda	13.81	8.86	1.94	1.26
Holothuroidea	6.25	0.71	1.61	0.11
Ophiuroidea	0.01	0.14	0.03	0.31
Sipunculida	0.51	0.36	0.35	0.65
Ascidiacea	0.02	0.01	0.03	<0.01
Other	0.22	0.06	0.79	0.26
Total Density (nos./m^2) or Biomass (g/m^2)	3133.9	3415.5	397.5	1407.1

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

Table 4. Percent contribution of dominant taxa to total infaunal numbers and biomass (wet weight) at each of two depths in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981, 1982, and August 1983[2]. Based on 526 airlift samples, each covering 0.0625 m^2, from each of 3 and 7 m depths.

Depth	Dominant Taxa by Numbers		% of total infaunal numbers	Dominant Taxa by Biomass		% of total infaunal biomass
3 m	Pholoe minuta	(P)	15.62	Mya truncata	(B)	43.18
	Nereimyra punctata	(P)	9.40	Astarte borealis	(B)	23.43
	Euchone analis	(P)	8.97	Astarte montagui	(B)	6.32
	Cingula castanea	(G)	7.18	Hiatella arctica	(B)	5.27
	Myriotrochus rinkii	(H)	6.25	Musculus discors	(B)	3.94
	Mya truncata	(B)	4.14	Serripes groenlandicus	(B)	2.53
	Spio spp.	(P)	3.92	Macoma calcarea	(B)	1.89
	Thyasiridae spp.	(B)	3.37	Myriotrochus rinkii	(H)	1.61
	Astarte borealis[3]	(B)	3.21	Pectinaria granulata	(P)	1.50
	Eteone longa	(P)	3.07	Trichotropis borealis	(G)	1.16
	Total % contribution		65.13	Total % contribution		90.83
	Total infaunal density (no./m^2)		3133.9	Total infaunal biomass (g/m^2)		397.5
7 m	Pholoe minuta	(P)	14.00	Mya truncata	(B)	45.68
	Thyasiridae spp.	(B)	13.80	Astarte borealis	(B)	17.64
	Astarte borealis[3]	(B)	8.77	Serripes groenlandicus	(B)	11.97
	Astarte montagui[3]	(B)	6.65	Macoma calcarea	(B)	6.10
	Macoma calcarea[3]	(B)	4.95	Astarte montagui	(B)	5.27
	Mya truncata	(B)	4.11	Clinocardium ciliatum	(B)	1.59
	Nuculana minuta	(B)	3.07	Hiatella arctica	(B)	1.50
	Cingula castanea	(G)	2.11	Musculus niger	(B)	1.15
	Trichotropis borealis	(G)	1.81	Pectinaria granulata	(P)	1.05
	Pectinaria granulata	(P)	1.67	Nuculana minuta	(B)	0.93
	Total % contribution		60.94	Total % contribution		92.88
	Total infaunal density (no./m^2)		3415.5	Total infaunal biomass (g/m^2)		1407.1

B = bivalve, P = polychaete, G = gastropod, H = holothuroid.

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

[3] Unidentified Astarte juveniles (≤3 mm) and Macoma juveniles (≤5 mm) are not included.

In general, the benthos of the study area at Cape Hatt appears to be typical of that in other nearshore high arctic areas. Several of the dominant infaunal species, including several of those contributing most to biomass (Mya truncata, Macoma calcarea, Astarte borealis, A. montagui, Serripes groenlandicus, and Pectinaria granulata), belong to the arctic Macoma community (Thorson 1957; Ockelmann 1958; Ellis 1960; Thomson 1982). This community is a widespread and common feature of nearshore high arctic areas and is displaced only under local circumstances (e.g., under estuarine influences). A quantitative analysis of community structure in the study bays is presented in a following section.

3.4.3 Distribution of Species

The distributions of 17 infaunal species at 3 m depth and 21 species at 7 m depth were examined individually based on density data. All of these species are included in the analyses of community structure (see Section 3.4.6), i.e. each comprised at least 0.9% of total infaunal numbers collected at either depth. Densities of these species in each bay and period and at each depth are given in Appendix D. Biomass data are given in Appendix E for the species dominating biomass at either depth (see Table 4), but detailed examination of the distribution of biomass was restricted to four (3 m) or five (7 m) species. There was high sample-to-sample variability in the biomasses of the other species, which were rare and were dominant only because individuals were large. Results of analyses of variance for densities and biomasses of the above-mentioned species and for major taxa (density of gastropods, density and biomass of bivalves, polychaetes and total infauna) are given in Appendices F to K and summarized in Tables 5 and 6.

3.4.3.a Spatial Effects

The smallest scale of variability apparent in our data is that among replicate samples within transects. Cross and Thomson (1981) reported relatively high variability on this scale for most groups and dominant species. Distributions of these species ranged from relatively even to relatively patchy, and even greater extremes of variability were observed for the many uncommon species in the study area. The next smallest scale of

Table 5. Summary of three-factor analyses of variance for the biomasses and densities of major taxa and dominant species of infauna at 3 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. Significance levels are shown for three analysis types[3]; a single value indicates that the results of all three analysis types were consistent (ns = $P>0.05$; * $P\leq0.05$; ** $P\leq0.01$; *** $P\leq0.001$).

Variable	Taxon	Source of Variation				
		Period	Bay	Period x Bay[5]	Transect (Bay)[4]	Per x Trans (Bay)[4]
Biomass	Total infauna	ns	***	ns	***	ns
	Polychaeta	ns	***/**/**	ns	***	ns/*/*
	Bivalvia	ns	***	ns	***	ns
	Mya truncata	ns	***	ns	***	ns
	Astarte borealis	ns	***	ns	***	ns
	Astarte montagui	ns	ns/*/***	ns	***	**/**/ns
	Macoma calcarea	ns	***	ns	***	ns
Density	Total infauna	ns/**/*	***	ns	***	ns/ns/*
	Polychaeta	ns/**/***	***	ns	**/**/ns	*/**/**
	Pholoe minuta	ns	**/***/**	ns	***	*/ns/*
	Nereimyra punctata	ns	*/*/ns	ns	***	ns
	Euchone analis	ns	***/**/***	ns	***	ns/*/*
	Spio spp.	***/*/6	ns/***/6	ns/ns/**	***/***/ns	**/***/***
	Eteone longa	ns	**/***/***	ns	***	ns
	Chaetozone setosa	ns/*/*	***	ns	***	ns
	Capitella capitata	ns	*/ns/ns	ns	***	ns
	Bivalvia	ns	***	ns	***	ns
	Mya truncata	**/ns/ns	***	ns	***	ns
	Thyasiridae spp.	ns	***	ns	***	ns
	Astarte borealis	ns	***	ns	***	ns
	Astarte montagui	ns	*/***/***	ns	***	*/ns/ns
	Astarte juveniles	ns	**/***/***	ns	***	*/ns/ns
	Musculus discors	ns	***	ns	***	ns
	Musculus juveniles	ns	***	ns	***/***/ns	ns
	Gastropoda	ns	***	ns	***/***/**	ns
	Cingula castanea	ns/ns/**	***	ns	***	ns
	Retusa obtusa	ns/*/***	***	ns	**/ns/ns	ns
	Holothuroidea					
	Myriotrochus rinkii	ns/ns/***	**/***/***	ns	***	*/ns/ns

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).
3 Results are shown for analyses involving (1) Bays 9, 10, 11 in 1980-1982, (2) Bays 7, 9, 10, 11 in 1981 and 1982, and (3) Bays 7, 9, 11 in 1981-1983; detailed ANOVA results are given in Appendices F to K.
4 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant ($P\leq0.05$), Transect (Bay) alone was used to test main effects.
5 The Period x Bay term is the test of oil effects.
6 Interpretation of main effects confounded by significant interaction of Period x Bay term.

Table 6. Summary of three-factor analyses of variance for the biomasses and densities of major taxa and dominant species of infauna at 7 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. Significance levels are shown for three analysis types[3]; a single value indicates that the results of all three analysis types were consistent (ns = $P>0.05$; * $P\leq0.05$; ** $P\leq0.01$; *** $P\leq0.001$).

Variable	Taxon	Source of Variation: Period	Bay	Period x Bay[5]	Transect (Bay)[4]	Per x Trans (Bay)[4]
Biomass	Total infauna	ns	**/**/***	ns	ns/**/**	ns
	Polychaeta	*/ns/ns	ns/*/**	ns	**/**/*	ns
	Bivalvia	ns	***/**/***	ns	ns/**/**	ns
	Mya truncata	ns/ns/*	**/ns/ns	ns	ns/*/**	ns
	Astarte borealis	ns	**/***/***	ns	*/ns/ns	ns
	Astarte montagui	ns	***	ns	**/***/**	ns/ns/*
	Macoma calcarea	*/ns/ns	***	ns	ns/***/***	ns
	Serripes groenlandicus	ns	***	ns	**/*/ns	ns
Density	Total infauna	***	***	ns	ns	ns
	Polychaeta	6/6/***	6/6/***	**/*/ns	*/**/*	ns
	Pholoe minuta	***	***	ns	**/**/ns	ns
	Pectinaria granulata	ns	ns	ns	***	ns
	Praxillella praetermissa	*/***/***	*/***/***	ns	*/ns/ns	ns
	Spio spp.	***/***/ns	***	ns	ns/*/ns	ns/ns/*
	Capitella capitata	*/**/**	ns	ns	***/*/***	ns
	Maldane sarsi	ns	***	ns	***	ns
	Bivalvia	ns	**/***/***	ns	ns/*/*	*/ns/ns
	Mya truncata	*/ns/ns	**	ns	**	ns
	Thyasiridae spp.	ns	***	ns	*/***/***	ns
	Astarte borealis	ns	*/***/***	ns	***/*/**	ns
	Astarte montagui	ns	***	ns	***	ns/ns/*
	Astarte juveniles	ns	***	ns	ns	ns
	Macoma calcarea	ns	***	ns	ns/***/***	***/ns/ns
	Macoma juveniles	**/*/6	**/***/6	ns/ns/*	ns/*/ns	ns
	Nuculana minuta	ns	***	ns	***/*/**	ns
	Musculus niger	ns	***	ns	***/*/ns	ns
	Musculus juveniles	***/***/**	***	ns	***	ns
	Serripes groenlandicus	ns	***	ns	**/*/ns	ns
	Gastropoda	**/**/ns	***	ns	ns/*/*	ns
	Cingula castanea	*/*/ns	***	ns	*/**/*	ns
	Trichotropis borealis	ns	***	ns	ns/**/**	ns
	Retusa obtusa	**/ns/ns	*/ns/*	ns	*/*/ns	ns
	Moelleria costulata	***/***/ns	***	ns	ns	ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

[3] Results are shown for analyses involving (1) Bays 9, 10, 11 in 1980-1982, (2) Bays 7, 9, 10, 11 in 1981 and 1982, and (3) Bays 7, 9, 11 in 1981-1983; detailed ANOVA results are given in Appendices F to K.

[4] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant ($P\leq0.05$), Transect (Bay) alone was used to test main effects.

[5] The Period x Bay term is the test of oil effects.

[6] Interpretation of main effects confounded by significant interaction of Period x Bay term.

variability, that among 50 m transects, was considerable for most of the species and groups examined, particularly at 3 m depth. This type of spatial variability is represented by the 'transect (bay)' term in Tables 5 and 6, which summarize the results of analyses of variance. Relatively few species were evenly distributed on a 50 m scale in the study bays: the gastropod Retusa obtusa at 3 m depth; and at 7 m, the polychaetes Praxillella praetermissa and Spio spp., the gastropod Moelleria costulata, and juvenile bivalves of the genera Astarte and Macoma.

The greatest variability in infaunal distribution was that among bays; of 61 variables tested (Tables 5 and 6), the only ones that did not differ among bays were the densities of the polychaetes Capitella capitata (both depths) and Pectinaria granulata (7 m depth only), and the biomass of Mya truncata (7 m only). At both depths, the highest total biomass and density of infauna were found in Bay 9, both before and after the dispersed oil release in late August 1981 (Fig. 5). At 7 m depth, total biomass and density were similar in the other three bays; at 3 m depth, total density and biomass of infauna were consistently lower in Bay 11 (surface release bay) than in the other three bays (Fig. 5).

In shallow water (3 m depth), bay differences were consistent (ranking of bays was 9>10>7>11) for most of the groups and species studied (Figs. 5 to 7). Notable exceptions were the polychaetes Nereimyra punctata and Chaetozone setosa, and the bivalve Musculus discors (most abundant in Bay 10); the polychaete Spio spp. (most abundant in Bay 7); and the polychaete Eteone longa (most abundant in Bay 11).

At 7 m depth, bay differences were much less consistent (Figs. 8 to 10). As was the case at the shallower depth, Bay 9 supported the highest numbers and biomasses of bivalves and total infauna; several bivalve species (Thyasiridae spp., Nuculana minuta, Musculus niger and Serripes groenlandicus), together with the dominant polychaete Pholoe minuta, reached their highest numbers in this bay. However, a similar number of taxa reached their highest densities or biomasses in Bay 11, in contrast to results from the shallower depth: the bivalves Mya truncata, Astarte borealis and A. montagui, the polychaetes Praxillella praetermissa and Maldane sarsi, and the

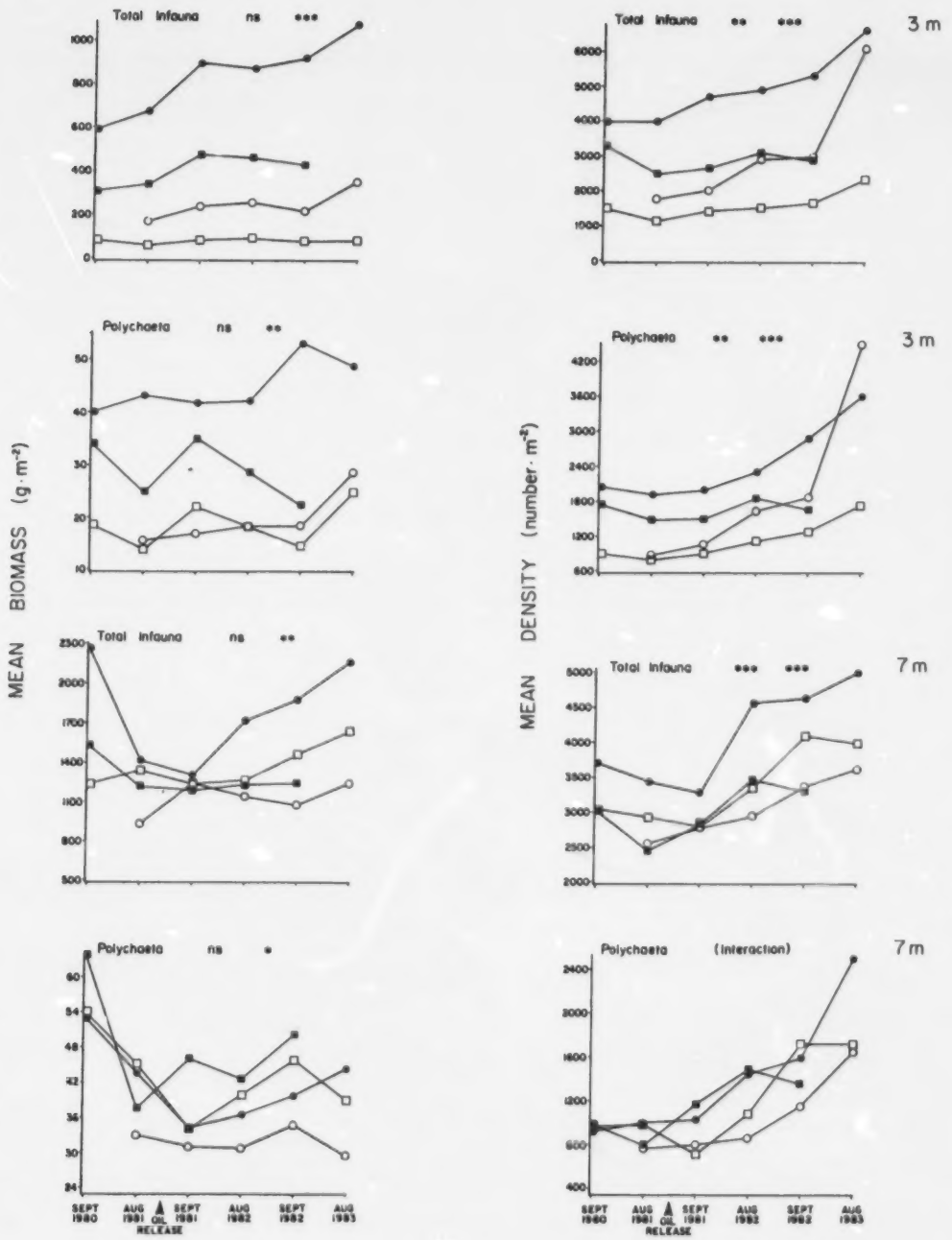


Figure 5. Mean biomass (g/m^2) and density ($no./m^2$) of total infauna and total polychaetes at 3 and 7 m depths in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples for each depth, bay and period, and significance levels are shown for period effects, followed by bay effects. Note that the ordinate does not always begin at zero. See Figure 7 for legend.

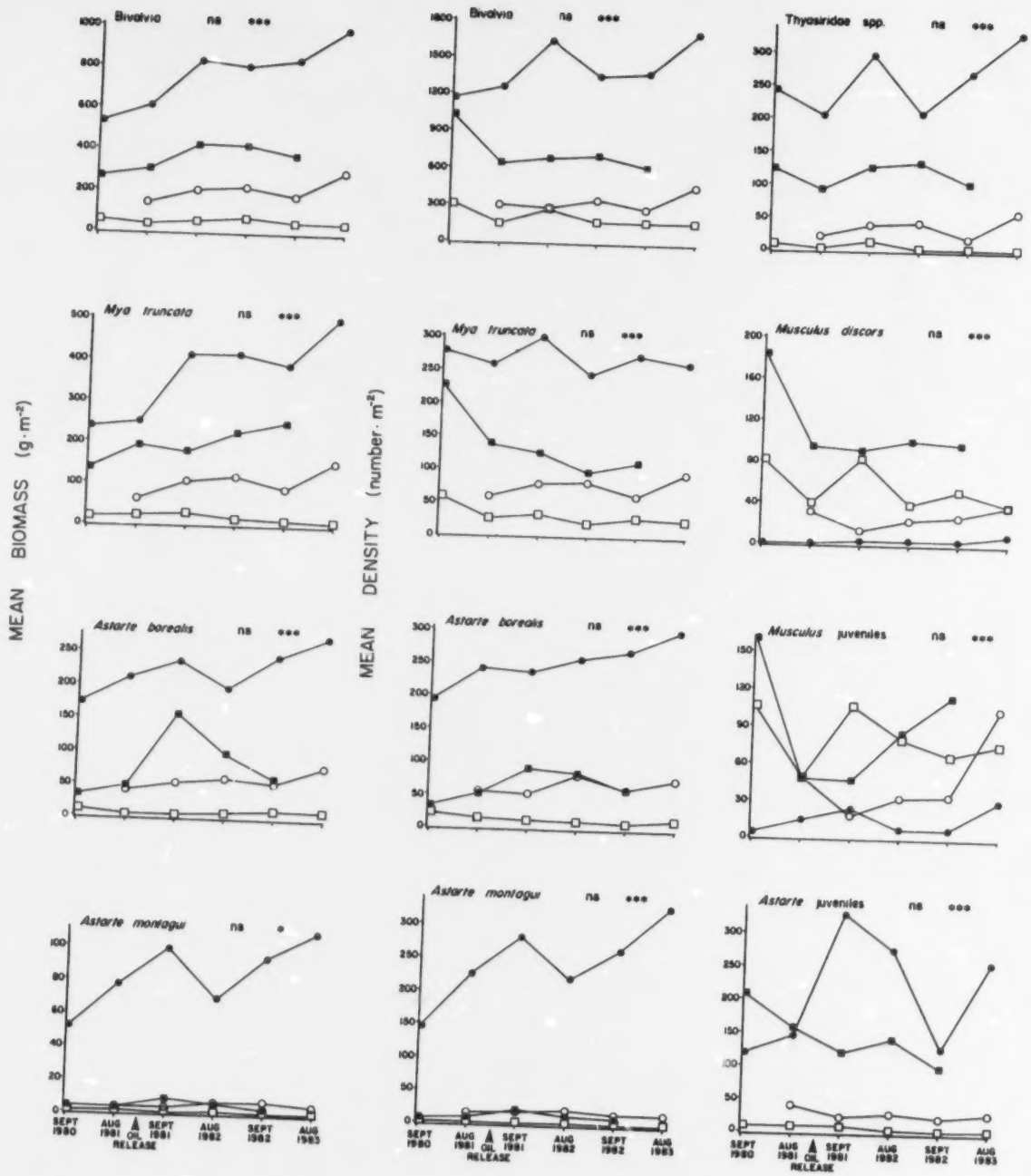


Figure 6. Mean biomass (g/m^2) and density ($no./m^2$) of total bivalves and dominant bivalve species at 3 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples for each bay and period, and significance levels are shown for period effects, followed by bay effects. See Figure 7 for legend.

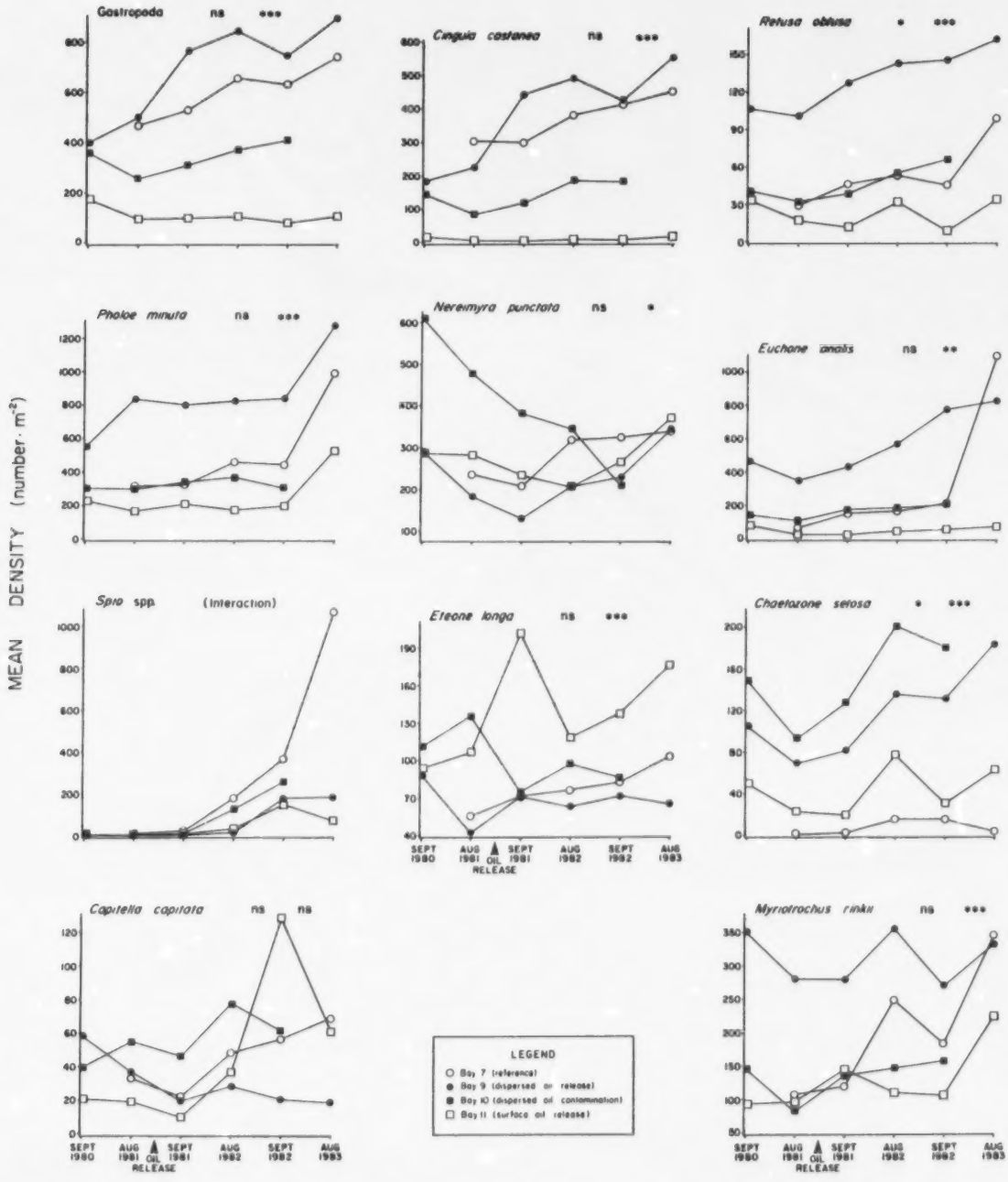


Figure 7. Mean density (no./m^2) of total gastropods and dominant gastropod, polychaete and holothurian species at 3 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples for each bay and period, and significance levels are shown for period effects, followed by bay effects. Note that the ordinate does not always begin at zero.

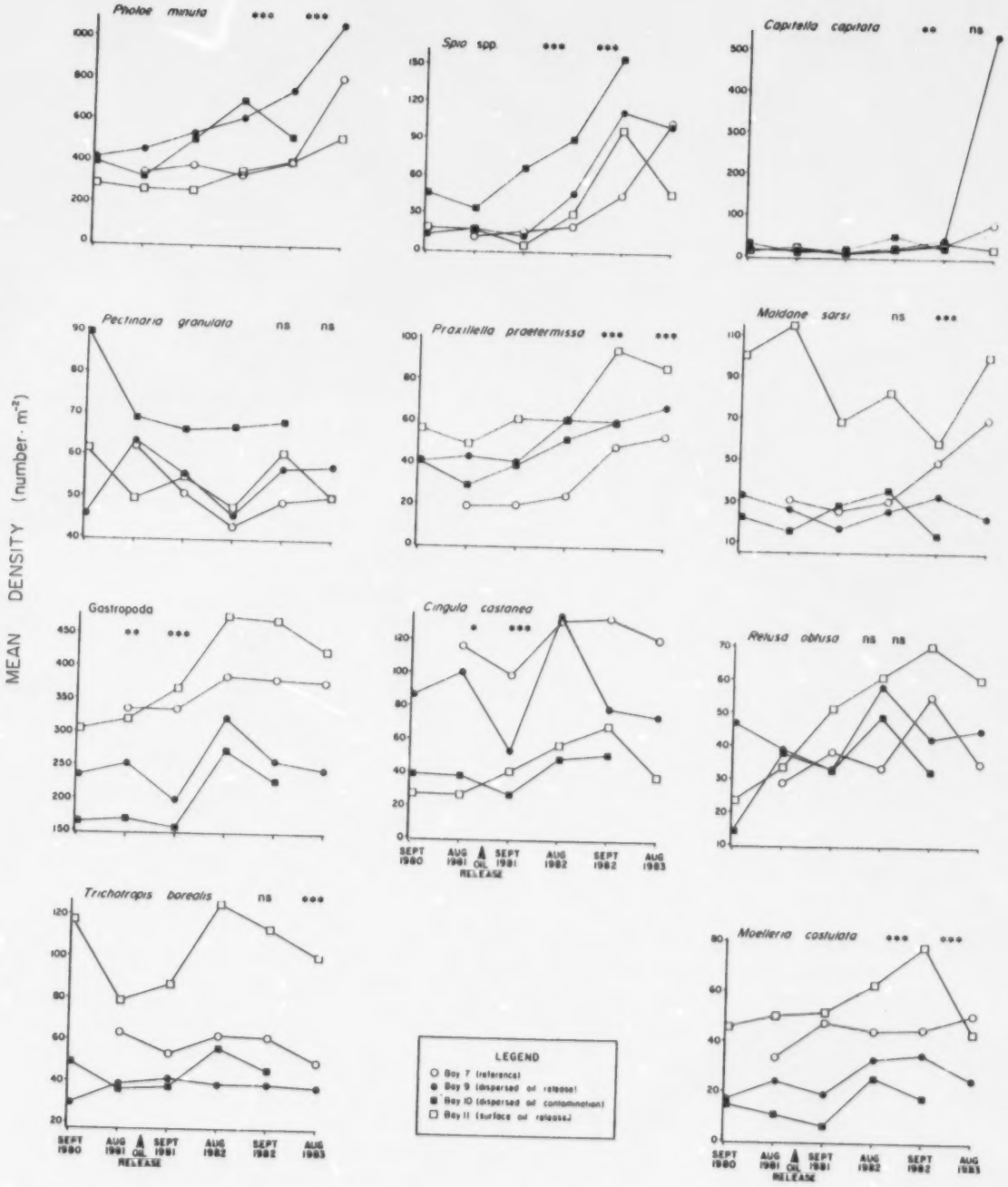


Figure 8. Mean density (no./m^2) of total gastropods and dominant polychaete and gastropod species at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples for each bay and period, and significance levels are shown for period effects, followed by bay effects. Note that the ordinate does not always begin at zero.

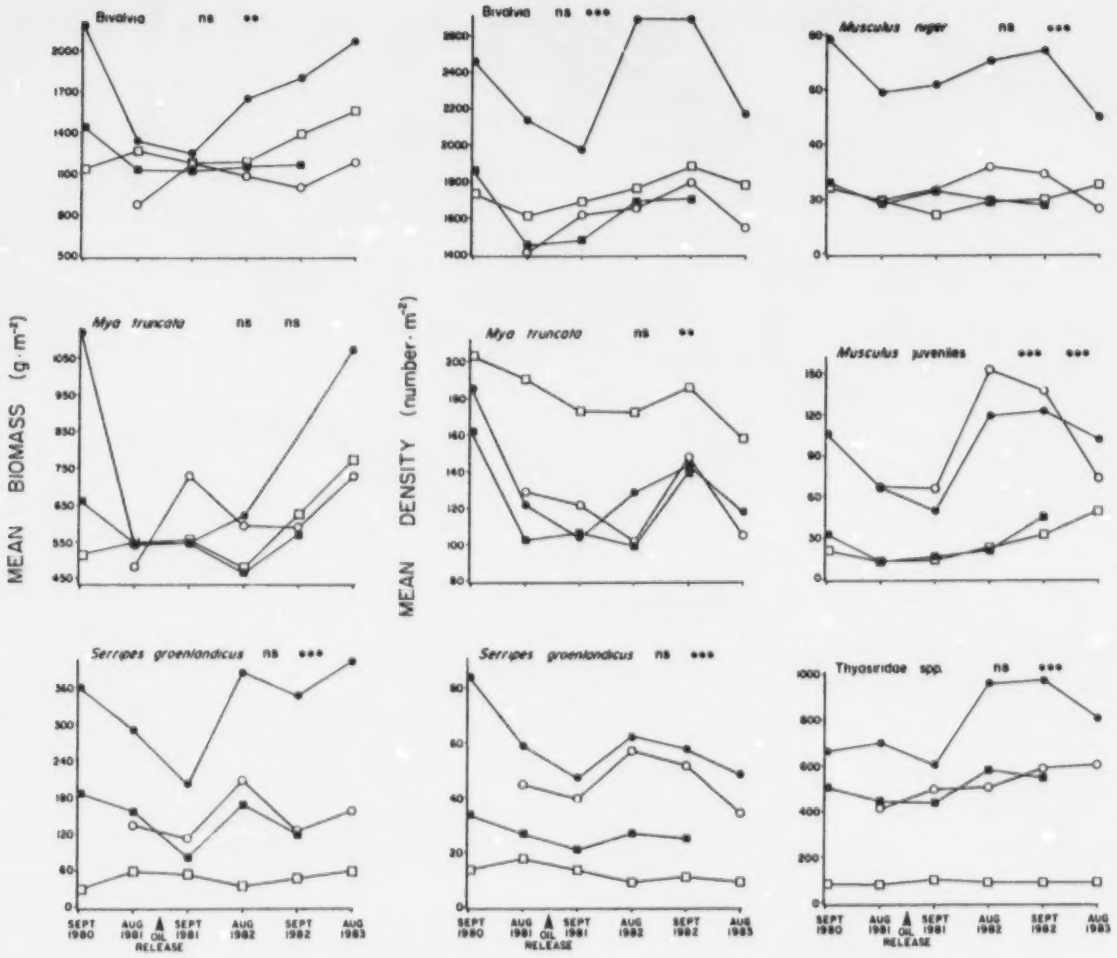


Figure 9. Mean biomass (g/m^2) and density ($no./m^2$) of total bivalves and dominant bivalve species at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples for each bay and period, and significance levels are shown for period effects, followed by bay effects. Note that the ordinate does not always begin at zero. See Figure 8 for legend.

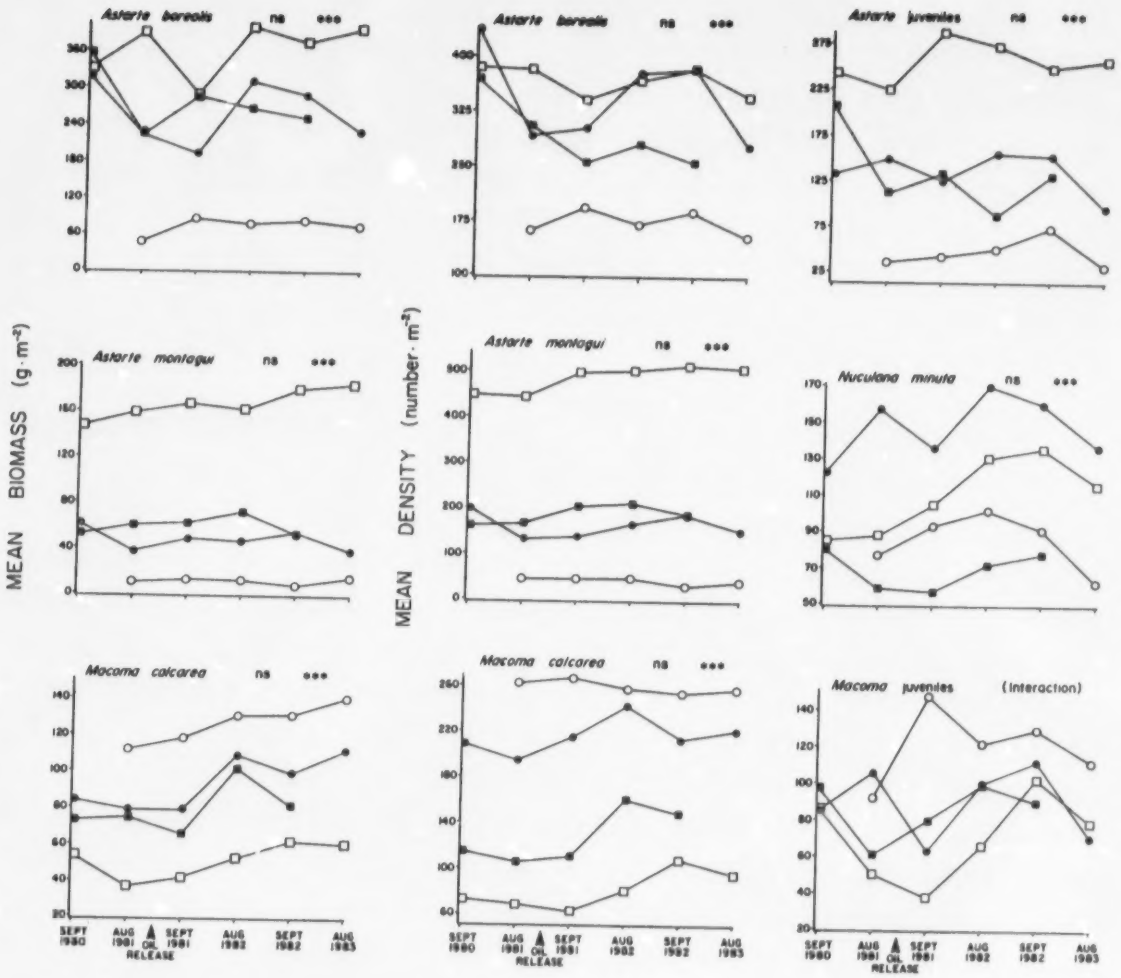


Figure 10. Mean biomass (mg/m^2) and density (no./m^2) of dominant bivalve species at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples for each bay and period, and significance levels are shown for period effects, followed by bay effects. Note that the ordinate does not always begin at zero. See Figure 8 for legend.

gastropods Trichotropis borealis, Retusa obtusa and Moelleria costulata. Bay 7 was lowest-ranked in terms of infaunal biomass, but several important species including Macoma calcarea, juveniles of the bivalve genus Musculus, and the dominant gastropod Cingula castanea were most abundant in this bay. As at 3 m depth, Bay 10 ranked in an intermediate position for most taxa, but was notable in that it supported the highest number of the polychaete Spio spp., and very few individuals of the gastropod species studied.

3.4.3.b Temporal Effects

In general, temporal change was a much smaller component of variability in the abundance and biomass of infauna than was spatial variability. The results of the three analysis types (involving different combinations of bays and sampling periods) were consistent in showing non-significant temporal change for many taxa. Furthermore, results of the three analysis types were often not consistent for those taxa where temporal variability was significant (Table 5 and 6). Biomass of dominant infauna, in particular, was relatively constant over the study period. Temporal variability in biomass data was apparent only at 7 m depth and only for three of eight variables; in each case temporal variability was marginally ($P>0.01$) significant for only one of three analysis types (Table 6).

Densities of infaunal species were somewhat more variable in time than were biomasses, particularly at 7 m depth. In nearly all cases at both depths, the temporal change involved increases in density from 1981 to 1982 or, more commonly, from 1981 to 1983 (Figs. 5, 7 to 9). Increases in density occurred in a number of polychaete species at both depths, in the gastropod Retusa obtusa at 3 m depth, and in juveniles of the bivalve genera Macoma and Musculus at 7 m depth (Tables 5 and 6). The same trend (increased density throughout the study period) was also apparent in a number of other species where temporal change was not statistically significant (Fig. 7 to 9). The densities of all gastropods and of the species Cingula castanea and Moelleria costulata at 7 m depth also increased over the study period, but the data for these taxa were more variable and there was some indication of seasonal (August to September) decreases in density (Fig. 8). It may be that some gastropods moved to shallower water in September; the tendency at 3 m depth was toward 'seasonal' increases in gastropod densities (Fig. 7).

Another less common temporal trend was apparent in the one analysis type that included data from the first sampling period (Tables 5 and 6). Between September 1980 and August 1981, there were decreases in density of Mya truncata at both depths, and in total polychaete biomass at 7 m depth. Similar but non-significant trends were apparent in the data for a number of other taxa, particularly bivalves, at both depths and most often in Bay 9 and/or Bay 10 (Figs. 6 and 9). Differences between these two sampling periods at 3 m depth may be spatial rather than temporal, because loss of transect markers necessitated the repositioning of 3 m transects in Bays 9 and 10 in August 1981. At 7 m depth, however, this was not the case, and the observed differences are definitely temporal.

Considered together, the two types of temporal change (decreased abundance in a few species from 1980 to 1981; increased abundance in a number of species in subsequent years) suggest the following possibility. The general increase in infaunal abundance may have been a recovery from some disturbance to the system in or prior to 1980 that caused widespread, albeit species-specific, mortality (e.g., high input of fresh water). It may be that small soft-bodied animals that had died were no longer present, whereas larger moribund animals, in particular bivalves, were still present in September 1980. If this was the case, then the system into which oil was introduced in 1981 was already responding to a disturbance, and the need for caution in distinguishing between pollution- and naturally-induced change (e.g., Cushing 1979; Clark 1982a,b) is particularly relevant. Another possibility that cannot be dismissed is that the infaunal community has been responding to disturbance caused by human activity at Cape Hatt. One possible source of disturbance is the increase in reworking and deposition of sediment as a result of sampling in the study bays; the airlift put approximately 0.5 m^3 of sediment into suspension in each bay and sampling period. Another possible source of disturbance is the presence of low concentrations of dispersed oil in all of the study bays for a lengthly period of time.

3.4.3.c Oil Effects

3.4.3.c.i Immediate Response

Oil was released on the surface of Bay 11 on 19 August 1981. Observations made by divers during the oil release indicated that some oil entered the water column, but it only reached a depth of approximately 1/2 m. On the first post-spill day, many dead and heavily oiled amphipods (Gammarus setosus) were observed at low tide in the intertidal zone, and at the same time some Gammarus were observed to be swimming just below the surface of the water. On 21 August (2 days post-spill) no apparent effects were noted in the benthos at either 3 or 7 m depths, and mysids were active in the water column. Dead fish larvae were observed on the surface just inside the (oiled) booms.

In contrast, the dispersed oil release produced marked short-term effects on the sub-tidal benthos in Bays 9 and 10. Initial observations during the release were discontinued due to lack of visibility, and observations were resumed approximately 6 hours after the oil release began. At this time visibility was still zero on the 7 m transect; at 3 m depth oil was still noticeable in the water column, but visibility was sufficiently good to allow observations. The only effect noted at this time was that burrowing bivalves had emerged onto the sediment surface. A few Mya truncata and Macoma sp. and numerous Serripes groenlandicus were observed. Some S. groenlandicus were gaping and making erratic movements with their extended feet. No surfaced bivalves were observed in Bays 7 or 10 immediately after the observations were made in Bay 9.

On the following two days, observations were made again in Bays 9 and 10 (approximately 24 and 48 hours post-spill), and in Bays 7 and 11 (approximately 48 hours post-spill). No effects were noted in Bays 7 or 11, but effects were apparent at both 3 and 7 m depths in both dispersed oil bays. In Bay 9, these effects were more extensive that on the previous day. Benthos affected included bivalves (Mya truncata, Astarte sp., Macoma sp. and Serripes groenlandicus), large errant polychaetes (Phyllodoce sp.), ophiuroids, asteroids, holothuroids, urchins, gastropods (including limpets),

sipunculids and fish. Bivalves and polychaetes that normally burrow were on the sediment surface and many bivalves were gaping. Fish were moving more slowly than usual, and the echinoderms and gastropods were lying on the substrate in unnatural positions (e.g., upside-down). Some individuals of each invertebrate group responded unusually slowly when prodded, and others did not respond. On the second post-spill day many S. groenlandicus were still on the substrate, and some were observed to be attempting to rebury themselves.

Density and biomass of Serripes groenlandicus on the sediment surface in the dispersed oil bays (estimated from randomly located quantitative photographs), together with density and biomass estimates of S. groenlandicus in the sediment before and after the dispersed oil release (based on airlift samples), were reported by Cross and Thomson (1982), and are summarized as follows:

		Density (no./m^2)				Biomass (g/m^2)			
		Bay 9		Bay 10		Bay 9		Bay 10	
Depth	Date(s)*	Subsurface	Surface	Subsurface	Surface	Subsurface	Surface[3]	Subsurface	Surface[3]
3 m	6-17 Aug.	29.3 ± 52.5	0	0	0	26.8 ± 48.2	0	0	0
	29 Aug.	-	7.8 ± 9.1	-	1.9 ± 3.1	-	27.2 ± 44.1	-	15.3 ± 26.8
	1-7 Sept.	16.7 ± 22.4	2.5 ± 6.6	0.7 ± 3.3	0	21.8 ± 57.7	9.6 ± 27.0	0.2 ± 0.9	0
7 m	6-17 Aug.	58.7 ± 45.9	0.9 ± 1.7	26.4 ± 25.8	0.3 ± 1.0	290.7 ± 286.0	5.6 ± 11.4	156.3 ± 182.1	1.6 ± 6.3
	29 Aug.	-	18.1 ± 13.9	-	9.3 ± 7.1	-	106.8 ± 88.9	-	67.3 ± 53.6
	1-7 Sept.	46.7 ± 35.0	9.7 ± 6.3	20.7 ± 19.2	2.3 ± 3.4	199.8 ± 175.8	66.7 ± 46.0	80.5 ± 118.8	18.0 ± 28.1

* 6-17 August = pre-spill; 29 August = second day following dispersed oil release; 1-7 September = post-spill.

In pre- and post-spill systematic sampling periods, Serripes groenlandicus was relatively abundant in the sediment at 7 m depth in all four bays, and at 3 m depth in Bay 9 (Fig. 9; Appendix D). Very few individuals were observed on the sediment surface at any time in Bays 7 or 11. Similarly, none or very few were photographed on the surface in the pre-spill periods in Bays 9 and 10. On the second post-spill day, however, numerous individuals were photographed on the sediment surface in the dispersed-oil bays. At that time in Bays 9 and 10 at 7 m depth, S. groenlandicus on the sediment surface represented approximately 31 and 35% of

pre-spill subsurface densities, and a similar proportion of subsurface biomasses (37 and 43% in Bays 9 and 10, respectively). In Bay 9 at 3 m depth, an estimated 27% of the population surfaced, but in this case the proportion in terms of biomass was much higher (approximately 100%). In Bay 10 at 3 m depth, a few large individuals were on the sediment surface following the oil release, but percentage estimates were not warranted because of the very low density estimates obtained by airlift sampling (see Appendix D).

Biomass of surfaced individuals was underestimated (Cross and Thomson 1982), so the proportion of biomass which came to the sediment surface in response to the dispersed oil was also underestimated. A higher proportion of biomass than of numbers implies a difference in size structure between subsurface and surfaced populations; this difference was also evident in length-frequency data. Individuals <10 mm in length were not recorded on the substrate surface and yet were common in airlift samples (Cross and Thomson 1982). Younger individuals are generally more susceptible to the effects of oil (e.g., Rice et al. 1975), and it is possible that the smaller individuals were killed outright or affected to the extent that they were unable to leave the substrate. There was no evidence of size-selective mortality in mean length data from 1982 and 1983 sampling periods (see Section 3.4.4), but some young individuals may have been killed. Such mortality may have been within natural variability, or may not have been detected because of the small number of Serripes groenlandicus collected.

Numbers of Serripes groenlandicus on the surface decreased in the 7-10 days following the oil release in all cases: At 7 m depth, numbers at the surface, relative to subsurface numbers in August, decreased from 31 to 17% and from 35 to 9% in Bays 9 and 10, respectively. A similar decrease (27 to 9%) occurred at 3 m depth in Bay 9.

These decreases in the densities of surfaced individuals in the 10 days following the oil release were, at least in part, a result of predation or scavenging by the urchin Strongylocentrotus droebachiensis (divers observations). This mortality must have represented only a small proportion of the population, however, as analysis results and inspection of the data showed no

significant decrease in densities of Serripes groenlandicus during post-spill sampling (see Section 3.4.3.c.ii and Appendices D and E). Our observations (above) that some individuals were attempting to rebury themselves also indicate that the decrease in numbers of surfaced individuals may have been, in part, a result of recovery and reburial in the sediment. In three of four experiments designed to approximate conditions in the dispersed oil bays, and carried out in aquaria at the Cape Hatt site, reburial of Serripes groenlandicus was evident within a seven day recovery period (Engelhardt et al. 1983). No significant mortality occurred in S. groenlandicus during these experiments except after a six-hour exposure to 500 ppm dispersed oil, the highest concentration tested.

3.4.3.c.ii Analysis Results

Oil and dispersed oil released at Cape Hatt did not cause large-scale mortality of benthic animals during the two years following the oil releases; no statistical treatment of the data is required to demonstrate this (see Figs. 5 to 10). The purpose of statistical tests, rather, was to examine more subtle changes in the densities or biomasses of infaunal animals. The criterion for recognizing a possible oil effect was decided, before the experiments began, to be the occurrence of a significant period x bay interaction in analysis of variance. At 3 and 7 m depths, 28 and 33 infaunal species- or group-variables, respectively, were tested. The interaction term, indicating a possible oil effect, was significant for only three (5%) of these 61 variables (Tables 5 and 6; Appendices F to K). This is exactly the number of seemingly significant effects that one would expect to find by chance if there were no real oil effects. Furthermore, results of the three types of tests (various combinations of bays and periods) were not consistent for any of the three variables. In the present section we examine possible sources of the few observed interactions in order to assess whether the changes could be attributable to the effects of oil or dispersed oil.

Analysis of the density of the polychaete Spio spp. at 3 m depth revealed a possible oil effect. The significant period x bay interaction was apparently attributable to the fact that changes in its density between September 1981 and August 1983 were not consistent among bays (Table 5;

Figure 7). Densities in every bay were low during 1980 and 1981, and increased considerably over the study period. However, increases in density between 1981 and 1982 occurred earlier in Bays 7 and 10 (by August) than in Bays 9 and 11 (by September). Furthermore, in 1983 there was a dramatic increase in density in the reference bay but not in Bays 9 or 11 (Fig. 7).

In the Disko Bay area of West Greenland, Spio filicornis apparently spawned in autumn and winter, and eggs were brooded in tubes until spring. At that time the larvae, though capable of swimming, metamorphosed into benthic forms in the parental tubes (Curtis 1977). Growth rates in S. filicornis were not measured, but in other species where growth was studied (including the spionid Polydora caulleryi) spawning occurred for the first time at the age of two years (Curtis 1977).

If a similar life history is assumed for Spio spp. at Cape Hatt, then the high densities observed in Bay 7 during 1983 consisted of the offspring of individuals that were themselves released from parental tubes during the spring of 1981. Individuals of this year class that were present in Bay 7 during the year of the oil releases were able to reproduce successfully in 1982-83 such that the population increased in 1983. In Bays 9 and 11, however, reproduction in 1982-1983 was at best only sufficient to maintain 1982 population levels; densities of Spio spp. in Bay 9 were similar in the two years, whereas in Bay 11, densities in 1983 were approximately half the 1982 values (Appendix D). Reproduction in Spio spp. in their second year at the time of the oil releases was also apparently affected; the delayed density increase in Bays 9 and 11 in 1982 indicates that either breeding or development during fall and winter 1981 was delayed in those locations. Assuming that the 1981-1982 density increases in Bays 7 and 10 and the 1982-1983 increase in Bay 7 represented natural occurrences, it can be concluded that the oil treatments in Bays 9 and 11 had an adverse affect on reproduction in Spio spp. The delay (1982) and lack (1983) of a population increase in both the dispersed oil and the surface oil bays suggest that oil in sediments (~4 and 1 ppm in September 1981 in Bays 9 and 11, respectively), rather than oil in the water during the dispersed oil release, was responsible for the observed effect.

A second possible oil effect was indicated for juveniles of the bivalve genus Macoma at 7 m depth. However, the bay x period interaction was significant only in the analysis type which excluded data from the first sampling period (all bays) and from Bay 10 (all periods) (Table 6). Between the second pre-spill and first post-spill periods, densities of Macoma juveniles increased in Bay 7, decreased in Bay 9 and were similar in Bay 11. Conversely, between the next two sampling periods (September 1981 and August 1982) densities decreased in Bay 7 and increased in Bays 9 and 11 (Fig. 10). One-factor analysis of variance for each of these changes in density, however, showed that only the 1981-1982 increase in Bay 11 was significant ($F = 9.36$, $df = 1,45$; $P = 0.004$). It is possible, therefore, that between September 1981 and August 1982, recruitment of Macoma juveniles from the plankton was enhanced in Bay 11 because of high oil concentrations in the sediment. It should be noted, however, that the observed increase in density was within the range of natural variability apparent in the reference bay and under pre-spill conditions (Fig. 10).

A third possible oil effect was indicated for the densities of total polychaetes at 7 m depth. In this case, the bay x period interaction was significant in two types of analysis (Table 6); no effect was indicated in the analysis which excluded data from Bay 10 and from the first sampling period. Inspection of the data (Fig. 5) shows a number of possible sources of interaction, but none of these appear to be related to oil concentrations in the water or sediments. Density changes in Bay 10 are likely responsible for the observed interaction: between August and September 1981, densities increased, relative to no change or decreases in the other bays; between August and September 1982 the converse was true. Bay 10, however, was exposed to intermediate concentrations of dispersed oil in 1981, and to intermediate oil concentrations in sediments during 1982. Furthermore, during 1981 and 1982, densities in both Bay 7 (reference) and Bay 9 (highest concentrations of dispersed oil) remained constant or increased somewhat between sampling periods. Finally, it should be pointed out that density changes were relatively small in all cases, and that densities increased somewhat in every bay over the study period. Thus, in this case we cannot attribute the significant interaction to any effects of oil.

In summary, oil and dispersed oil released at Cape Hatt clearly did not cause large scale mortality of benthic infauna during the two years following the experimental oil releases. We tested for subtle changes in 28 and 33 species- or group-variables at 3 and 7 m depths, respectively, and found changes that might be related to oil in only one taxon at each of 3 m and 7 m depths. The polychaete Spio spp. was apparently affected by oil in sediments at 3 m depth in both the dispersed oil release and surface oil release bays. Breeding in two-year-olds or development of their offspring in the fall and winter following the oil releases was delayed in Bays 9 and 11, whereas the year class that was produced in the oil release year was able to reproduce successfully (in 1982-1983) only in the reference bay. At 7 m depth, oil in the sediments of Bay 11 may have enhanced the settlement of juveniles of the bivalve genus Macoma in the summer of 1982, but the observed density increase was within the range of natural variability.

The lack of any major effects of oil or dispersed oil is likely a result of the rather low concentrations of oil in the sediments of any bay. Experimental studies have shown that benthic animals are killed or begin to die after one to eight weeks exposure to 250-1000 ppm of crude oil in sediments (Gordon et al. 1978; Roesijadi et al. 1978; Roesijadi and Anderson 1979; Augenfeld 1980; Augenfeld et al. 1980). The above authors found a range of response from no mortality to total mortality depending on the species. With longer exposures, lower concentrations can cause mortality. Twenty-five weeks exposure to 109 ppm in sediment caused a significant decline in density of macrofauna in experimental ecosytems (Grassle et al. 1980).

3.4.3.d Capitella capitata

The polychaete worm Capitella capitata is an opportunistic species that is often used as an indicator of pollution (Grassle and Grassle 1977; Pearson and Rosenberg 1978). After an oil spill in Buzzards Bay, Massachusetts, C. capitata 'monopolized the biologically denuded substrata at the heavily oiled stations for the first eleven months after the spill' (Sanders et al. 1980).

At Cape Hatt, mean densities of Capitella capitata at most bay/period/depth combinations ranged from 8.3 ± SD 10.6 to 80.0 ± 190.5 individuals/m^2 over the study period (Appendix D; Figs. 7 and 8). Two higher mean densities (in Bay 11, 3 m depth, September 1982; Bay 9, 7 m depth, August 1983) each resulted from the presence of large numbers of C. capitata in only one of 24 samples (111 and 743 individuals, respectively). Analyses of variance showed that the density of this species differed significantly among transects at both depths in all types of analysis, indicating a patchy distribution within bays. Differences among bays, however, were significant only at 3 m depth and only in one type of analysis (Table 5). Period differences were evident only at 7 m depth and in all types of analyses (Table 6); densities of C. capitata were generally higher in 1982 and 1983 than in 1980 or 1981 (Fig. 8).

Interaction effects (test for oil effects) were not significant at either depth in any of the three analysis types. In 1982, the sample from 3 m depth in Bay 11 that contained a large number of Capitella capitata (Transect 1) did not come from the transect with the highest oil concentration (Transect 3; Boehm et al. 1983). The other sample with many C. capitata was from 7 m depth in Bay 9 in 1983. Hydrocarbon levels on 7 m transects in Bay 9 were not measured in 1983, but there was a relatively even distribution of oil among the tissue plots that were located along, and about 5 m seaward, of these transects (P. Boehm, pers comm.). Thus there was no evidence of an oil effect on the density of C. capitata.

3.4.4 Size-Frequency Distribution

Exposure to oil may cause size-selective mortality of benthic animals in a variety of ways. Not all life stages of marine animals are equally susceptible to the effects of oil (Rice et al. 1975; Linden 1978). Larval stages are generally more susceptible than are adults (Wells and Sprague 1976). Dow (1978) has demonstrated, on the other hand, an instance of selective mortality of large individuals of a bivalve species. The juveniles inhabited clean surface sediments, but as they grew they tended to burrow deeper into the substrate and died when they reached an oil-contaminated layer.

Mean lengths of five bivalve species, and oral ring diameters of a holothurian, are shown in Table 7. For two of these species, the bivalves Mya truncata and Serripes groenlandicus, mean sizes of the populations are underestimated because damaged individuals were not measured, and broken shells were more common among the larger individuals in our samples. There is no reason to expect any systematic differences among bays or periods in the sizes of damaged animals, however, so the analyses presented below are still valid. Analysis of size data was not performed for S. groenlandicus because of the small sample sizes (Table 7).

3.4.4.a Spatial Effects

Mean lengths (log transformed) of individuals in each sample were compared among bays, periods and transects, using three-factor nested analyses of variance (Table 8). Small-scale patchiness (transect variability) in the mean sizes of the animals tested was evident for all three species at 3 m depth; differences in results of the three analysis types, however, indicate that mean sizes of Myriotrochus rinkii and Mya truncata varied among transects only in Bay 10 (dispersed oil contamination bay). At 7 m depth, Astarte montagui and Macoma calcarea showed consistently even mean sizes among transects, whereas M. truncata was consistently variable in size on a small scale. Transect variability in the mean size of Astarte borealis was significant only in the analysis types which included data from Bay 10 (Table 8).

These transect effects, particularly at 3 m depth, may be the result of patchy settlement patterns in juvenile bivalves or of periodic mortality due to ice scour or variations in temperature and salinity. Each of these physical factors (particularly ice scour) may vary on a small scale, and any resultant mortality would cause a shift toward smaller (newly settled) bivalves in those areas. Curtis and Petersen (1977) reported size class heterogeneity on an even smaller scale (several metres) in Macoma calcarea and the polychaete Pectinaria granulata near Disko Island, West Greenland, and attributed this to settling behaviour and competition between year classes.

Table 7. Mean lengths (mm) of six species of benthic infauna from four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Data are expressed as mean ± standard deviation; numbers in parentheses are number of individuals collected and measured.

Taxon	Period	3 m Depth				7 m Depth			
		Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Nya truncata	Pre-spill 1	–	12.7 ± 7.4 (371)	9.4 ± 7.6 (310)	8.5 ± 5.5 (81)	–	26.7 ± 14.4 (232)	18.2 ± 13.6 (195)	16.2 ± 13.0 (251)
	Pre-spill 2	13.1 ± 7.7 (60)	14.8 ± 7.1 (295)	14.9 ± 9.0 (149)	10.7 ± 6.5 (27)	19.0 ± 12.3 (125)	20.2 ± 12.1 (130)	21.9 ± 13.2 (90)	16.2 ± 12.0 (230)
	Post-spill 1	17.3 ± 7.4 (72)	15.9 ± 8.0 (358)	13.9 ± 9.2 (143)	10.1 ± 7.1 (39)	21.3 ± 13.7 (126)	22.0 ± 13.4 (102)	22.5 ± 12.7 (113)	17.8 ± 11.1 (191)
	Post-spill 2	12.5 ± 9.6 (105)	19.4 ± 8.4 (280)	16.2 ± 10.9 (131)	13.6 ± 7.2 (23)	21.9 ± 13.6 (127)	23.8 ± 11.4 (164)	22.3 ± 12.6 (132)	17.1 ± 10.7 (211)
	Post-spill 3	14.2 ± 9.8 (69)	18.0 ± 7.4 (334)	17.1 ± 10.6 (122)	10.4 ± 6.0 (37)	22.4 ± 14.0 (157)	24.1 ± 12.3 (170)	23.2 ± 10.8 (136)	18.5 ± 11.0 (223)
	Post-spill 4	13.7 ±10.2 (131)	18.3 ± 9.1 (328)	–	5.8 ± 6.9 (34)	23.1 ± 13.9 (102)	29.6 ± 12.4 (129)	–	21.5 ± 12.2 (189)
Nucula calcarea	Pre-spill 1	–	11.6 ± 4.6 (53)	10.6 ± 4.1 (37)	15.0 ± 6.8 (8)	–	12.8 ± 5.4 (299)	14.8 ± 6.5 (164)	15.5 ± 6.6 (104)
	Pre-spill 2	16.2 ± 3.0 (11)	12.6 ± 5.3 (67)	14.4 ± 6.8 (18)	0	13.2 ± 5.1 (364)	13.2 ± 5.1 (265)	15.3 ± 6.6 (136)	13.2 ± 6.7 (99)
	Post-spill 1	14.6 ± 5.8 (18)	11.8 ± 5.2 (72)	11.5 ± 4.9 (24)	23.0 (1)	13.4 ± 5.1 (376)	12.6 ± 4.9 (298)	14.9 ± 6.5 (147)	15.5 ± 6.8 (81)
	Post-spill 2	14.3 ± 4.1 (13)	12.3 ± 4.9 (59)	15.5 ± 6.3 (34)	11.0 ± 3.5 (3)	13.8 ± 5.1 (369)	13.8 ± 4.7 (347)	14.9 ± 6.4 (222)	13.8 ± 6.9 (118)
	Post-spill 3	14.0 ± 5.2 (14)	11.7 ± 5.0 (86)	14.3 ± 5.5 (19)	16.7 ± 3.8 (3)	13.9 ± 5.0 (360)	13.7 ± 5.0 (291)	14.1 ± 6.1 (204)	13.4 ± 6.5 (159)
	Post-spill 4	17.6 ± 5.6 (18)	11.0 ± 5.2 (59)	–	20.5 ± 5.1 (4)	14.5 ± 4.8 (372)	14.6 ± 4.7 (311)	–	14.3 ± 6.7 (137)
Astarte borealis	Pre-spill 1	–	12.8 ± 7.5 (287)	12.4 ± 9.5 (48)	10.2 ± 6.8 (31)	–	12.4 ± 7.1 (653)	12.6 ± 8.4 (549)	13.3 ± 8.5 (572)
	Pre-spill 2	12.1 ± 7.4 (81)	12.9 ± 7.5 (357)	11.6 ± 8.5 (74)	9.1 ± 5.1 (21)	9.6 ± 5.6 (239)	12.2 ± 7.6 (431)	11.9 ± 7.6 (431)	13.8 ± 8.5 (566)
	Post-spill 1	13.8 ± 7.8 (76)	14.2 ± 7.7 (351)	16.0 ± 10.2 (132)	10.3 ± 6.2 (16)	10.4 ± 6.0 (286)	11.9 ± 7.0 (445)	13.9 ± 8.7 (377)	13.8 ± 8.5 (496)
	Post-spill 2	11.2 ± 7.6 (121)	12.6 ± 7.0 (382)	13.4 ± 9.4 (124)	9.6 ± 8.7 (16)	10.1 ± 6.1 (252)	13.1 ± 7.4 (560)	12.5 ± 8.6 (415)	13.7 ± 8.9 (549)
	Post-spill 3	13.0 ± 7.8 (89)	13.0 ± 7.7 (389)	12.5 ± 9.0 (88)	15.1 ± 10.5 (12)	10.0 ± 6.0 (274)	12.6 ± 7.2 (567)	12.9 ± 8.4 (374)	13.2 ± 8.5 (569)
	Post-spill 4	13.5 ± 7.9 (112)	13.4 ± 7.6 (445)	–	12.6 ± 7.7 (20)	10.7 ± 6.4 (227)	13.5 ± 7.3 (406)	–	14.4 ± 8.9 (514)
Astarte montagui	Pre-spill 1	–	11.0 ± 2.8 (217)	12.2 ± 3.0 (10)	10.7 ± 6.7 (3)	–	9.4 ± 3.7 (299)	9.3 ± 4.1 (239)	9.7 ± 3.8 (671)
	Pre-spill 2	9.6 ± 3.7 (24)	10.5 ± 3.1 (337)	10.7 ± 3.8 (13)	17.0 ± 0.0 (2)	8.7 ± 3.8 (64)	9.0 ± 4.2 (197)	10.2 ± 3.9 (237)	10.2 ± 3.8 (661)
	Post-spill 1	8.9 ± 4.2 (27)	10.7 ± 2.9 (422)	11.2 ± 2.8 (32)	0	9.5 ± 3.6 (66)	9.8 ± 3.7 (204)	9.7 ± 3.9 (301)	9.9 ± 4.0 (723)
	Post-spill 2	10.6 ± 3.3 (32)	10.6 ± 3.0 (327)	11.4 ± 3.8 (18)	12.0 ± 6.1 (3)	9.1 ± 4.2 (68)	9.3 ± 3.8 (246)	10.1 ± 3.9 (315)	9.5 ± 3.9 (747)
	Post-spill 3	11.3 ± 4.3 (23)	10.7 ± 2.9 (395)	9.1 ± 4.2 (13)	0	9.0 ± 3.7 (43)	9.4 ± 3.6 (279)	9.3 ± 3.6 (275)	10.0 ± 3.9 (769)
	Post-spill 4	10.2 ± 3.3 (24)	10.4 ± 2.9 (491)	–	0	10.6 ± 3.9 (58)	9.4 ± 3.7 (225)	–	10.2 ± 3.9 (761)
Serripes groenlandicus	Pre-spill 1	–	12.8 ± 5.9 (30)	13.5 ± 12.0 (2)	26.0 (1)	–	24.5 ± 15.2 (89)	29.0 ± 12.2 (34)	19.2 ± 9.2 (18)
	Pre-spill 2	0	16.0 ± 4.2 (30)	0	6.3 ± 3.9 (4)	15.3 ± 11.2 (37)	26.5 ± 12.8 (46)	28.1 ± 15.4 (21)	20.6 ± 10.4 (18)
	Post-spill 1	0	14.9 ± 10.9 (18)	10.0 (1)	0	19.9 ± 12.1 (37)	24.8 ± 11.6 (44)	18.8 ± 10.9 (18)	25.2 ± 12.3 (10)
	Post-spill 2	4.6 ± 1.5 (11)	17.4 ± 12.7 (26)	1.0 (1)	28.8 ± 17.7 (5)	15.6 ± 14.2 (65)	30.5 ± 13.0 (58)	22.6 ± 17.5 (24)	22.3 ± 14.6 (9)
	Post-spill 3	10.0 (1)	15.4 ± 10.8 (39)	0	23.0 (1)	15.7 ± 12.3 (58)	26.1 ± 14.8 (50)	15.8 ± 16.3 (23)	19.2 ± 13.7 (10)
	Post-spill 4	6.0 ± 2.9 (4)	9.2 ± 11.0 (25)	–	0	17.2 ± 14.3 (34)	30.3 ± 15.6 (43)	–	24.7 ± 15.5 (10)
Myriotrochus rinkii[3]	Pre-spill 1	–	2.3 ± 1.1 (519)	2.8 ± 1.0 (216)	2.7 ± 1.0 (139)	–	3.1 ± 1.0 (127)	4.0 (1)	3.6 ± 0.8 (40)
	Pre-spill 2	2.6 ± 0.9 (159)	2.3 ± 0.8 (417)	3.1 ± 0.8 (115)	2.7 ± 1.1 (142)	3.1 ± 0.8 (36)	3.1 ± 0.9 (48)	3.5 ± 0.7 (12)	3.5 ± 0.5 (6)
	Post-spill 1	2.4 ± 0.9 (176)	2.3 ± 0.8 (417)	2.8 ± 1.0 (202)	2.4 ± 1.0 (207)	3.0 ± 0.9 (6)	2.9 ± 0.8 (92)	3.5 ± 2.1 (2)	2.8 ± 0.9 (16)
	Post-spill 2	2.5 ± 1.1 (361)	2.6 ± 0.9 (523)	2.8 ± 1.0 (209)	2.9 ± 1.0 (144)	3.6 ± 1.0 (25)	3.1 ± 0.9 (120)	3.5 ± 0.7 (2)	3.7 ± 1.4 (7)
	Post-spill 3	2.3 ± 1.2 (263)	2.7 ± 0.8 (388)	2.7 ± 1.0 (223)	2.8 ± 1.1 (134)	3.6 ± 1.0 (18)	3.4 ± 0.9 (95)	4.0 (1)	2.7 ± 1.1 (11)
	Post-spill 4	2.1 ± 1.0 (503)	2.5 ± 1.0 (486)	–	2.7 ± 1.1 (309)	3.5 ± 1.6 (6)	3.1 ± 1.1 (61)	–	2.1 ± 1.5 (9)

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).
[3] Diameter of calcareous oral ring.

Table 8. Results of analyses of variance on mean lengths (in each sample) of four bivalve species, and mean oral ring diameter of the holothurian *Myriotrochus rinkii*, in four bays[1] at Cape Hatt, northern Baffin Island during September 1980, August and September 1981 and 1982, and August 1983[2]. P-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

Analysis	Depth	Species	Source of Variation and Numerator df[3] Period 4 (3)	Bay 2 (3)	Period x Bay[4] 8 (9)	Transect (Bay) 6 (8)	Per x Tran (Bay) 24 (24)	Residual df	No. of samples
Bays 9, 10, 11/ 1980-1982	3 m	*Myriotrochus rinkii*	5.13 **	18.12 ***	0.35 ns	3.10 **	0.82 ns	283	328
		Astarte borealis	0.54 ns	2.05 ns	0.36 ns	6.44 ***	0.86 ns	199	243
		Mya truncata	4.03 **	13.26 ***	0.32 ns	8.13 ***	0.80 ns	248	293
	7 m	*Astarte montagui*	1.47 ns	1.97 ns	0.61 ns	1.77 ns	1.27 ns	305	350
		Astarte borealis	0.09 ns	5.57 **	0.77 ns	2.63 *	1.00 ns	309	354
		Mya truncata	0.77 ns	17.28 ***	1.63 ns	2.21 *	1.03 ns	305	350
		Macoma calcarea	[5]	[5]	2.76 *	0.78 ns	0.52 ns	307	352
Bays 7, 9, 10, 11/ 1981, 1982	3 m	*Myriotrochus rinkii*	4.64 **	11.84 ***	0.68 ns	2.29 *	0.96 ns	305	353
		Astarte borealis	0.68 ns	1.31 ns	0.38 ns	6.37 ***	1.21 ns	215	262
		Mya truncata	1.64 ns	9.33 ***	1.60 ns	3.83 ***	0.48 ns	260	308
	7 m	*Astarte montagui*	0.91 ns	1.90 ns	0.44 ns	1.78 ns	1.37 ns	297	345
		Astarte borealis	0.50 ns	13.86 ***	1.17 ns	2.11 *	1.05 ns	319	367
		Mya truncata	1.04 ns	5.61 **	0.66 ns	3.43 ***	1.18 ns	324	372
		Macoma calcarea	1.77 ns	3.73 *	2.14 ns	0.97 ns	0.57 ns	325	373
Bays 7, 9, 11/ 1981-1983	3 m	*Myriotrochus rinkii*	5.39 **	10.94 ***	1.70 ns	1.39 ns	0.95 ns	293	338
		Astarte borealis	0.61 ns	1.03 ns	0.41 ns	8.74 ***	1.24 ns	199	243
		Mya truncata	[5]	[5]	4.30 **	1.20 ns	0.45 ns	232	277
	7 m	*Astarte montagui*	0.96 ns	2.80 ns	0.57 ns	1.66 ns	1.32 ns	273	318
		Astarte borealis	1.16 ns	39.02 ***	1.47 ns	1.35 ns	0.89 ns	298	343
		Mya truncata	2.29 ns	10.08 ***	0.41 ns	3.65 **	1.28 ns	304	349
		Macoma calcarea	[5]	[5]	2.81 *	0.85 ns	0.58 ns	304	349

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

[3] Numerator df are shown for analyses involving 3 bays and 5 periods (3/5) followed by those involving 4 bays and 4 periods (4/4) in parentheses. Denominator df for transect effects are residual df. Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period effects and Period x Bay effects; denominator df are 30 (3/5 analysis) or 32 (4/4 analysis). Where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test Period, Bay and Period x Bay effects; denominator df are 6 (3/5 analysis) or 8 (4/4 analysis).

[4] The Period x Bay term is the test of oil effects.

[5] Interpretation of main effects confounded by significant interaction of Period x Bay term.

At 3 m depth, differences in mean lengths among bays were evident for Mya truncata and Myriotrochus rinkii but not Astarte borealis (Table 8). M. rinkii was consistently larger in Bays 10 and 11 (surface oil release bay), and smaller in Bays 7 (reference bay) and 9 (dispersed oil release bay) (Table 7). The ranking of bays for mean size of M. truncata (9>10>7>11) was the same as that for its density (Fig. 6). Very few individuals >25 mm and >35 mm in length occurred in Bays 11 and 7, respectively, whereas individuals >45 mm in length were relatively common in Bays 9 and 10 (Fig. 11). Smaller sizes and lower densities of M. truncata in Bays 7 and 11 may have been a result of sediment characteristics or reduced water circulation. The high gravel content and shallow depth of the sediment at 3 m depth in Bay 7 relative to the other bays (Tables 1 and 2) may have made it more difficult for this deeply burrowing species to become established there. Furthermore, mean grain size was higher in Bays 7 and 11 than in Bays 9 and 10 (Table 2). Bay 11 is the most enclosed of the study bays, and reduced nearshore circulation may have resulted in (1) a lower food supply for filter feeders such as M. truncata, or (2) more prolonged periods of reduced salinity from surface run-off.

At 7 m depth, mean lengths of three of the four bivalve species differed among bays (Table 8). The exception was Astarte montagui. Mya truncata showed the same bay differences (9>10>7>11) as at 3 m depth. Large individuals were well represented in each bay, and differences in mean size at this depth apparently resulted from variations in the abundance of smaller individuals: M. truncata <10 mm in length were most abundant in Bay 11 and least abundant in Bay 9 (Fig. 11). Astarte borealis was smaller in Bay 7 than in the other three bays, and was also much less abundant in this bay than in any other (Fig. 10). Serripes groenlandicus (not analyzed) also appeared to be smallest in Bay 7 (Table 7). Macoma calcarea was somewhat smaller in Bays 7 and 9 than in the other two bays (Table 7); this trend is similar to that shown by the holothurian Myriotrochus rinkii at 3 m depth.

3.4.4.b Temporal Effects

Differences among periods were significant only for Myriotrochus rinkii and Mya truncata at 3 m depth (Table 8). Variation in the size of the oral ring diameter of M. rinkii at 3 m depth was apparently seasonal. In six of eight cases (two years in four bays), mean sizes were smaller in September than in August (Table 7). This size change may have been the result of mortality in large individuals or recruitment of juveniles. In the case of M. truncata, size differences were apparent at 3 m depth only in the analysis that included data from the first sampling period (Table 8). In each of the three bays sampled in 1980, mean sizes were lower in September 1980 than in most other sampling periods (Table 7). Small M. truncata (0-3 mm and 4-6 mm size classes) were relatively more abundant in the first sampling period than in any other, except in Bay 11 during August 1983 (Fig. 11). The 0-3 mm and 4-6 mm size classes likely represent newly-settled and 1-year-old individuals, respectively. Thorson (1936) reported 1-year-olds to be 3-6 mm long (in June) in Northeast Greenland, and Petersen (1978) found that M. truncata in Northwest Greenland were 2-4 mm long by the end of their first winter. In both locations, larvae settled to the bottom from the plankton in summer. Length/age equations for M. truncata collected at Cape Hatt in September 1980 give a length of about 7 mm for a 1-year-old (Green et al. in prep.). Hence the temporal variability in the size of M. truncata is attributable, in part, to reduced recruitment in 1981, and in part to mortality of individuals that were 1-year-old in 1980.

3.4.4.c Oil Effects

A possible oil effect was indicated for Mya truncata at 3 m depth, but only by the analysis that excluded data from Bay 10 and from September 1980 (Table 8). Likely sources of the observed interaction were the marked annual (September to August) decreases in mean size (1) in Bay 7 between 1981 and 1982, relative to increases in Bays 9 and 11, and (2) in Bay 11 between 1982 and 1983, relative to little change in Bays 7 and 9. Because annual decreases in mean size were restricted in one case (1981-1982) to the reference bay, and in the other case (1982-1983) to the surface oil release bay, it seems unlikely that the interaction was related to the oil treatments.

An annual decrease in the mean size of these populations may represent recruitment of small individuals to the populations (in this case, settlement of planktonic larvae), mortality of large individuals, or both. Inspection of size-frequency data (Fig. 11; shaded portion = 3 m) indicates that both recruitment and mortality may have contributed to the observed interaction. Mortality of large individuals was indicated in Bay 11, where the decrease in mean size between 1982 and 1983 was attributable both to increased recrutiment and decreased densities of large individuals (Fig. 11). This may indictate an effect of oil in Bay 11 sediments on large Mya truncata, but this interpretation is ambiguous because of the low numbers collected there at any time. These low numbers may indicate (1) an artefactual "oil effect" attributable to sampling error, or (2) that Mya truncata was only marginally established in this location under pre-spill conditions, and thus was unusually susceptible to the effects of oil.

Recruitment was estimated as the proportion of the population that was in the smallest (1-3 mm) size class during August, as there was no evidence of increase in this size class between August and September sampling periods (Fig. 11; see also Section 3.4.4.b). Recruitment was strong only in Bay 10 in 1980 (based on September data); was poor in each bay in 1981; was markedly improved only in Bay 7 (and somewhat improved in Bay 10) in 1982; and was relatively good in each of Bays 7, 9 and 11 in 1983 (Fig. 11). The pattern of recruitment in 1982 may indicate an effect of oil in the sediments of Bays 9 and 11, and, to a lesser extent, in Bay 10. However, the recruitment success in each bay in 1983, together with variability in recruitment during pre-spill sampling periods, provides evidence that recruitment in Mya truncata was not necessarily affected by the oil treatments. Indeed, the spatial and temporal pattern of recruitment may have been related to changes in abundance of Stictyosiphon tortilis, one of the dominant understory macroalgae in the study area (see Section 3.6). Recruitment success in M. truncata closely paralleled increases in biomass of this alga within the study bays: viz. only in Bay 10 in 1980; in Bays 7 and 10 in 1982; and in each bay studied in 1983. Young M. truncata have been reported to attach to benthic algae (Ockelmann 1958, p. 148); thus their planktonic larvae may select substrates with high algal biomass on which to settle. Another possible explanation of the variability in recruitment may be periodic

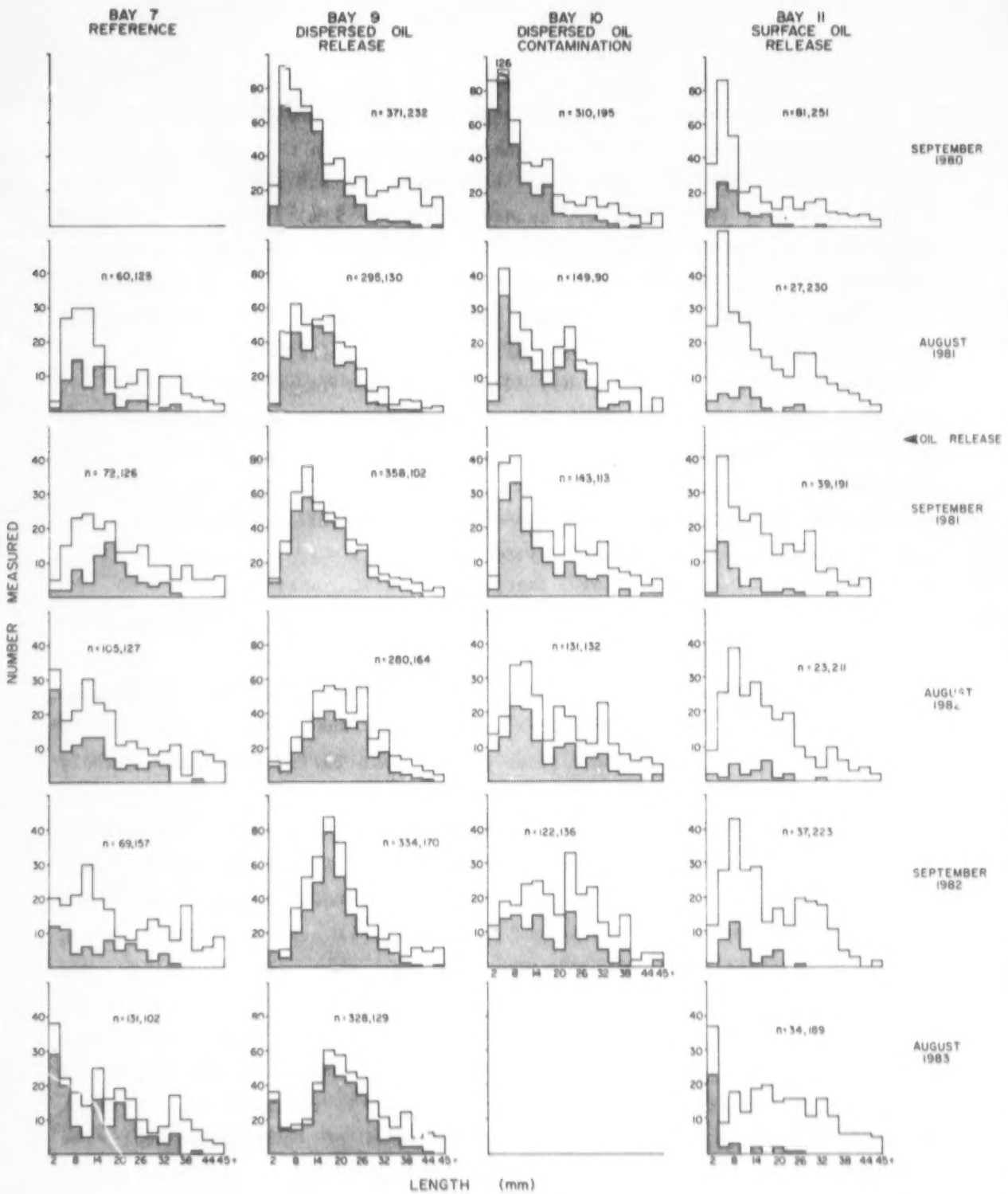


Figure 11. Length-frequency distributions of Mya truncata at 3 and 7 m depths in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Sample sizes are given for 3 m depth (lower portion of each histogram), followed by 7 m depth (upper portion), and represent all undamaged individuals in 24 samples from each depth, bay and period. Note differences in vertical scales.

spawning in the parent populations, such as that reported for M. truncata in Northeast Greenland (Thorson 1936, p. 105).

A second possible oil effect was indicated for mean size of **Macoma calcarea at 7 m depth.** This effect was evident as a significant interaction in each of the analysis types that included data from only three bays (Table 8). Inspection of the data, however, gives no indication that the observed inconsistencies in size changes among bays were attributable to the effects of oil. In Bays 7 (reference) and 9 (dispersed oil release), a similar increase in mean size occurred throughout the study period, from approximately 13 to 14.5 mm (Table 7). More detailed size information contained in length-frequency histograms (Fig. 12) also shows the general similarity in population structure between Bays 7 and 9. Mean size in Bay 10 was somewhat greater (14.1 to 15.3 mm) than in Bays 7 and 9, and was more or less constant over the study period (Table 7). The higher mean size relative to Bays 7 and 9 was apparently attributable to higher numbers of large (>25 mm) individuals and lower numbers of small (6-10 mm) individuals (Fig. 12). The greatest period-to-period variability in mean size occurred in Bay 11; size in September was considerably greater than in August during the first four sampling periods, but the trend was reversed in the last two periods (Table 7). The former trend was, at least in part, a result of lower numbers of 6-10 mm individuals in September than in August (Fig. 12). Sample sizes of M. calcarea in Bay 11, however, were smaller than in any other bay; hence mean size would be more susceptible to random variation in the size distribution of large individuals. Most of the variability in population structure of M. calcarea at Cape Hatt was spatial (Fig. 12). Variability among periods was also evident, both between pre-spill sampling periods and among sampling periods following the oil releases in 1981. The period x bay interaction effects do not appear to be attributable to effects of oil or dispersed oil.

Macoma calcarea, unlike other arctic species of Macoma, apparently has a pelagic and planktotrophic form of larval development (Ockelmann 1958). The observed spatial and temporal variation in population structure at Cape Hatt may, therefore, be a result of variability in recruitment of juveniles that is unrelated to local conditions. The rare and irregular occurrence of M.

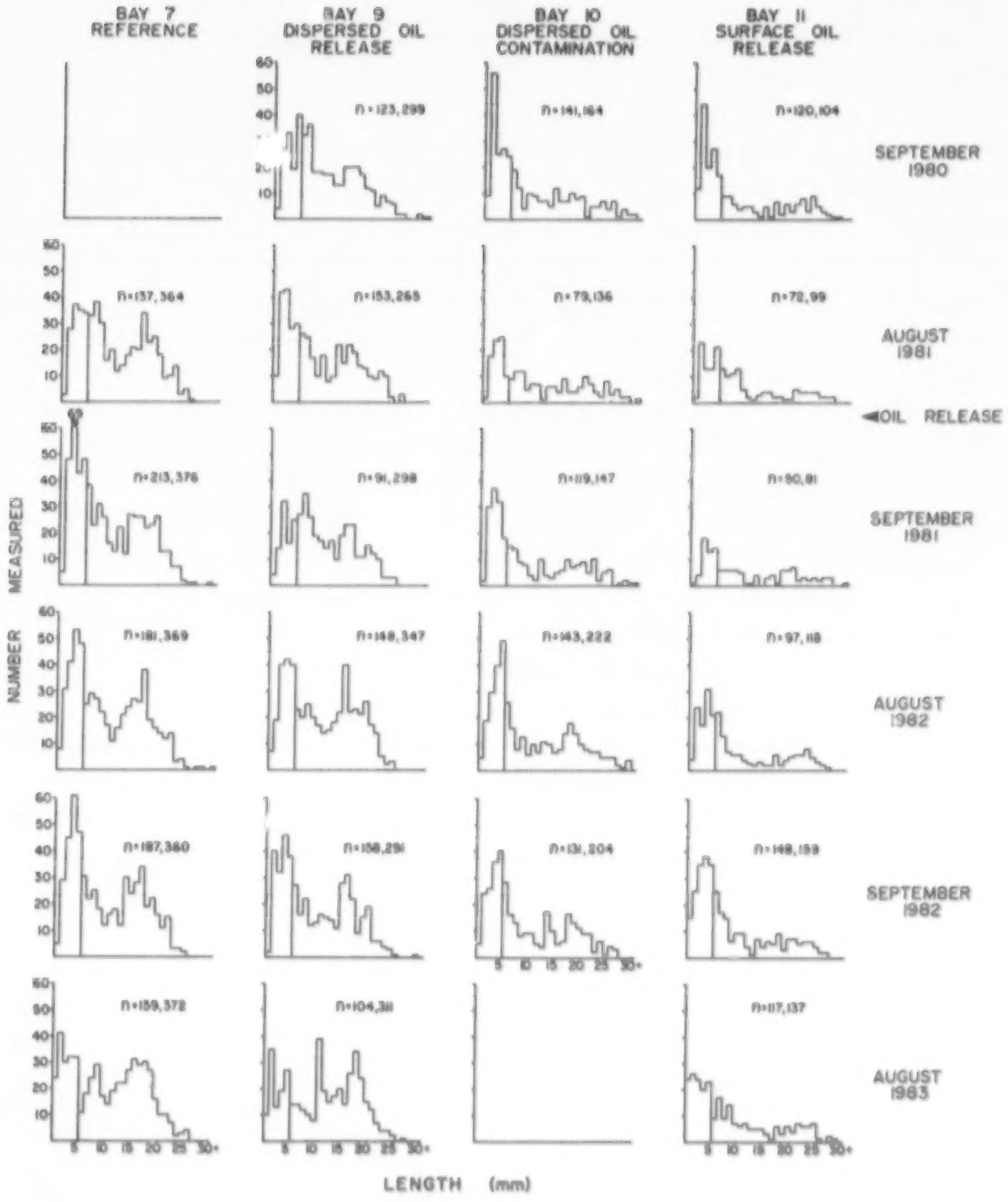


Figure 12. Length-frequency distributions of Macoma calcarea (≥6 mm long) and Macoma juveniles (1-5 mm) at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre-spill and post-spill sampling periods from September 1980 to August 1983. Sample sizes are given for Macoma juveniles, followed by Macoma calcarea, and represent all undamaged individuals in 24 samples from each bay and period.

calcarea in East Greenland, and in particular the scarcity of young individuals, led Ockelmann (1958, p. 242) to suggest that this species either does not spawn every year or is subject to periodic failure of its larval development. In West Greenland M. calcarea is abundant, but Petersen (1978) also reported considerable variability in recruitment among the years and locations studied. Recruitment at Cape Hatt is difficult to evaluate. Macoma juveniles likely include M. moesta and M. loveni, but the overwhelming dominance of M. calcarea at Cape Hatt indicates that juveniles are primarily the latter species. Population structure in juveniles (1-5 mm) was sometimes unimodal and sometimes bimodal (Fig. 12), and the rather prolonged spawning period (late June to early August; Thorson 1936, Petersen 1978), together with conflicting reports on growth rates, make it difficult to assess whether juveniles are newly settled, 1-year-olds or 2-year-olds. Length at 1 year has been variously reported as <1 mm to 3 mm (Petersen 1978), and 4-7 mm or 5-7 mm (Thorson 1936; Green et al. in prep.).

There was no evidence of any oil effect on mean sizes of Astarte borealis or A. montagui (Table 8). There was also no evidence of oil effects on the densities of these species, or of unidentified Astarte juveniles (Tables 5 and 6). Unlike Mya truncata or Macoma calcarea, species of Astarte in the Arctic are thought to have direct (rather than larval) development. In East Greenland, Astarte spp. produce eggs with a mucous and adhesive membrane, and these are thought to be attached to the substrate (Thorson 1936, p. 57; Ockelmann 1958, p. 238). Hence, local conditions (including the presence of oil) may affect recruitment of juveniles in a different way than would be the case for species with pelagic development.

In order to assess the effects of oil and dispersed oil on eggs, and hence recruitment, in Astarte borealis and A. montagui at Cape Hatt, we have presented length-frequency histograms for Astarte juveniles (1-3 mm) and small (4-10 mm) individuals of the two Astarte species (Fig. 13). In East Greenland, A. borealis spawned in October and were 3-6 mm long at one year of age (in September; Thorson 1936). Green et al. (in prep.), however, estimated that 1-year-olds at Cape Hatt (in September 1980) were 1.4 mm in Bays 9 and 10, and 1.8 mm in Bay 11; three-year-olds were 3.2 and 4.0 mm in length in Bays 9 and 10, and in Bay 11, respectively. In either case, Figure 13 should include ages up to at least three years.

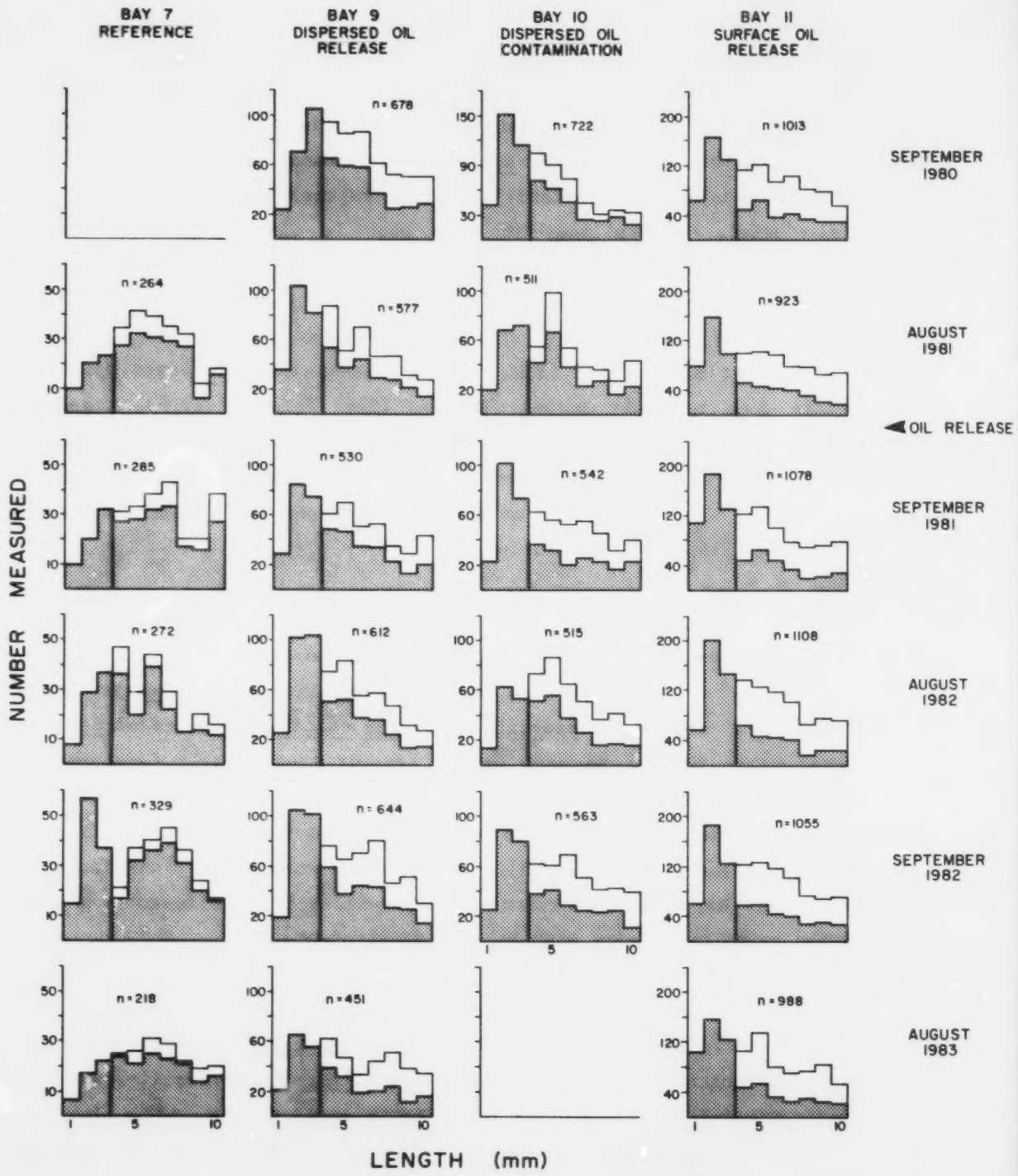


Figure 13. Length-frequency distributions of Astarte juveniles (1-3 mm, shaded), Astarte borealis (4-10 mm, shaded) and Astarte montagui (4-10 mm, not shaded) at 7 m depth in four bays at Cape Hatt, northern Baffin Island during pre- and post-spill sampling periods from September 1980 to August 1983. Sample sizes are given for undamaged individuals ≤10 mm in length in 24 samples from each bay and period. Note differences in vertical scales.

Figure 13, in general, corroborates the slower growth rates reported by Green et al. (in prep.) for the lower end of the range reported by Thorson (1936). In most cases there is a distinct mode at 2 mm or at 2 and 3 mm length, which would represent juveniles produced in the previous year. Inspection of the size-frequency distributions shows no evidence of oil effects on recruitment in Astarte spp. The histograms for Bays 9, 10 and 11 (oiled bays) are similar to each other, both before and after the oil releases, and recruitment was good in most cases. Reduced numbers of juveniles occurred in Bay 10 in August of both years studied (i.e. pre- and post-spill). There was an overall reduction in numbers in Bay 9 in August 1983, but the shape of the histogram is similar to shapes in all other periods. Finally, the least stable population structure, and the most variability in population structure among periods, occurred in Bay 7; strong recruitment to the population occurred only in 1982, and most of these juveniles were no longer present in 1983 (Fig. 13). Both species of Astarte were much less abundant in this bay than in any other (Fig. 10), and A. borealis was also smaller (Table 7). Thus, variation in population structure was primarily spatial, and, except in the reference bay, recruitment was strong in most bays and years. There was no evidence of oil effects on the population structure of Astarte juveniles or of small A. borealis and A. montagui.

In summary, data on mean size and population structure for four bivalve species and the holothurian Myriotrochus rinkii at Cape Hatt showed considerable spatial and temporal (seasonal and annual) variability. The only evidence of oil-related effects on size-frequency distributions was mortality of large Mya truncata at 3 m depth in Bay 11. The low numbers of individuals present, however, render this interpretation ambiguous. Most of the observed variability was likely attributable to natural variability (1) in recruitment of larvae with pelagic or direct development, (2) in growth rates, and/or (3) in mortality of young or old individuals.

3.4.5 Weight-Length Relationships of Bivalves

Exposure to crude oil may cause physiological changes in marine invertebrates. In bivalves these changes may be reflected in the dry weight-length relationship (Thomas 1978; Stekoll et al. 1980). The dry weight-length relationship of four bivalve species was used to test for sublethal effects of oil in the experimental bays at Cape Hatt.

For three species of bivalves (Mya truncata, Macoma calcarea and Astarte borealis), we measured and weighed approximately 50 individuals from the middle transect at 7 m depth in each of the three bays sampled in September 1980. Analysis of scatter plots of the original data and of residuals produced by regression analyses indicated that the weight-length relationship of these animals was best expressed by a power curve ($y = ax^b$) rather than by exponential ($y = ae^x$), linear ($y = a + bx$) or logarithmic ($y = a \log x$) functions (Cross and Thomson 1981). This type of weight-length relationship was expected a priori and is typical of most animals.

Weight-length analyses in the present report include a fourth species, Serripes groenlandicus, a fourth bay (Bay 7), and all six sampling periods. Analyses of covariance were used to assess among-bay and among-period variations in the slopes of the regression lines and in dry weights adjusted for length (Table 9). The slope is the power to which length must be raised in order to estimate weight (b in the expression $y = ax^b$). The first part of the analysis of covariance is a test of equality of slopes. If the slopes for different bays and periods are similar, then the rate of gain in weight with increasing length is consistent. If slopes are significantly different among bays or periods, interpretation of the remainder of the analysis for that effect or interaction is ambiguous. The second part of the analysis compares weights in different bays and periods after adjustment for any differences in length. If adjusted weights (i.e. weight at a standard length) are significantly different, then at any given length animals are heavier in some bays or periods than in others.

Results of analyses of covariance (Table 9) showed considerable temporal and spatial variability, both in the slopes of the weight-length regression lines and the dry weights adjusted for length. Bay differences were common

Table 9. Analyses of covariance of difference in dry meat weight, using length as the covariate, for bivalves collected at a depth of 7 m in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. P-values are given with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

			Equality of Group Means				Equality of Slopes			
Analysis	Species	df[3] →	Period 4 (3)	Bay 2 (3)	Period x Bay 8 (9)	Denominator df	Period 4 (3)	Bay 2 (3)	Period x Bay 8 (9)	Denominator df
Bays 9, 10, 11/ 1980-1982	Astarte borealis		9.12 ***	-[4]	-[4]	685	2.00 ns	4.68 **	2.81 **	671
	Macoma calcarea		5.30 ***	2.76 ns	2.06 *	652	1.82 ns	1.53 ns	1.05 ns	638
	Mya truncata		4.71 ***	5.82 **	0.89 ns	720	1.39 ns	1.77 ns	0.42 ns	706
Bays 7, 9, 10, 11/ 1981, 1982	Astarte borealis		-[4]	15.89 ***	-[4]	745	3.27 *	1.67 ns	1.99 *	730
	Macoma calcarea		4.41 **	-[4]	2.96 **	724	2.55 ns	9.18 ***	1.02 ns	709
	Mya truncata		2.78 *	-[4]	0.84 ns	797	0.94 ns	3.88 **	1.07 ns	782
	Serripes groenlandicus		7.55 ***	9.42 ***	3.70 ***	345	1.00 ns	0.85 ns	1.72 ns	330
Bays 7, 9, 11/ 1981-1983	Astarte borealis		-[4]	15.59 ***	-[4]	706	3.98 **	0.52 ns	2.21 *	692
	Macoma calcarea		15.34 ***	-[4]	3.98 ***	699	2.19 ns	12.44 ***	0.98 ns	685
	Mya truncata		4.29 **	-[4]	1.36 ns	732	0.88 ns	7.48 ***	1.04 ns	718
	Serripes groenlandicus		5.76 ***	15.48 ***	5.14 ***	338	0.58 ns	0.66 ns	1.73 ns	324

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 , 3 and 4 (September 1981, August 1982, September 1982, August 1983).
[3] Numerator df are shown for analyses involving 3 bays and 3 years, followed by those involving 4 bays and 2 years (in parentheses).
[4] Results of 'Equality of Group Means' not shown because of heterogeneity of slopes of regression lines for the effect.

both in slopes and in adjusted weights, and Bay 7 (reference) appeared to be important in these differences. Regression line slopes in Macoma calcarea and Mya truncata differed among bays only in the analysis types that included Bay 7 (Table 9). Regression line slopes for M. truncata and M. calcarea were least in individuals from Bay 7, i.e. large individuals were lighter, and small individuals were heavier, than in the other bays. After adjustment for length, mean weights of Astarte borealis and Serripes groenlandicus were higher in Bay 7 than in any other bay. **Temporal differences** in slopes were evident only for A. borealis, and only in the two analysis types that included data from Bay 7 and excluded data from the first sampling period (Table 9). In every other case (i.e. each species in each analysis type), dry weights adjusted for length differed among sampling periods. Adjusted weights of M. truncata and S. groenlandicus were least in September 1982, and M. calcarea was lightest in September 1981. Each of these species was heaviest in August, either in 1981 (S. groenlandicus) or in 1982 or 1983 (M. truncata, M. calcarea). In contrast, adjusted mean weight of A. borealis (based on only one analysis type; Table 9) was highest in September 1980 and least in August 1982.

Bay x period interactions were significant in the cases of regression line slopes for Astarte borealis and adjusted mean dry weights of Macoma calcarea and Serripes groenlandicus (Table 9). In each case, results of all analysis types were consistent. Each of these interactions indicates the possibility that oil affected weight-length relationships. There was no evidence of oil effects on the weight-length relationship in Mya truncata.

Inspection of the weight vs. length regression lines for Astarte borealis in each period and bay (Fig. 14) shows little evidence of progressive change in slopes through time. The only such progressive change occurred in large individuals in Bay 10; in this case the greatest apparent differences were those between the two pre-spill sampling periods. Hence, there is no evidence that either of the oil releases affected weight-length relationships in A. borealis.

The period x bay interaction effect in adjusted dry meat weight of Macoma calcarea is evident in Figure 15. Also shown is an estimated correction for length of time in alcohol (dotted lines for August 1983; see

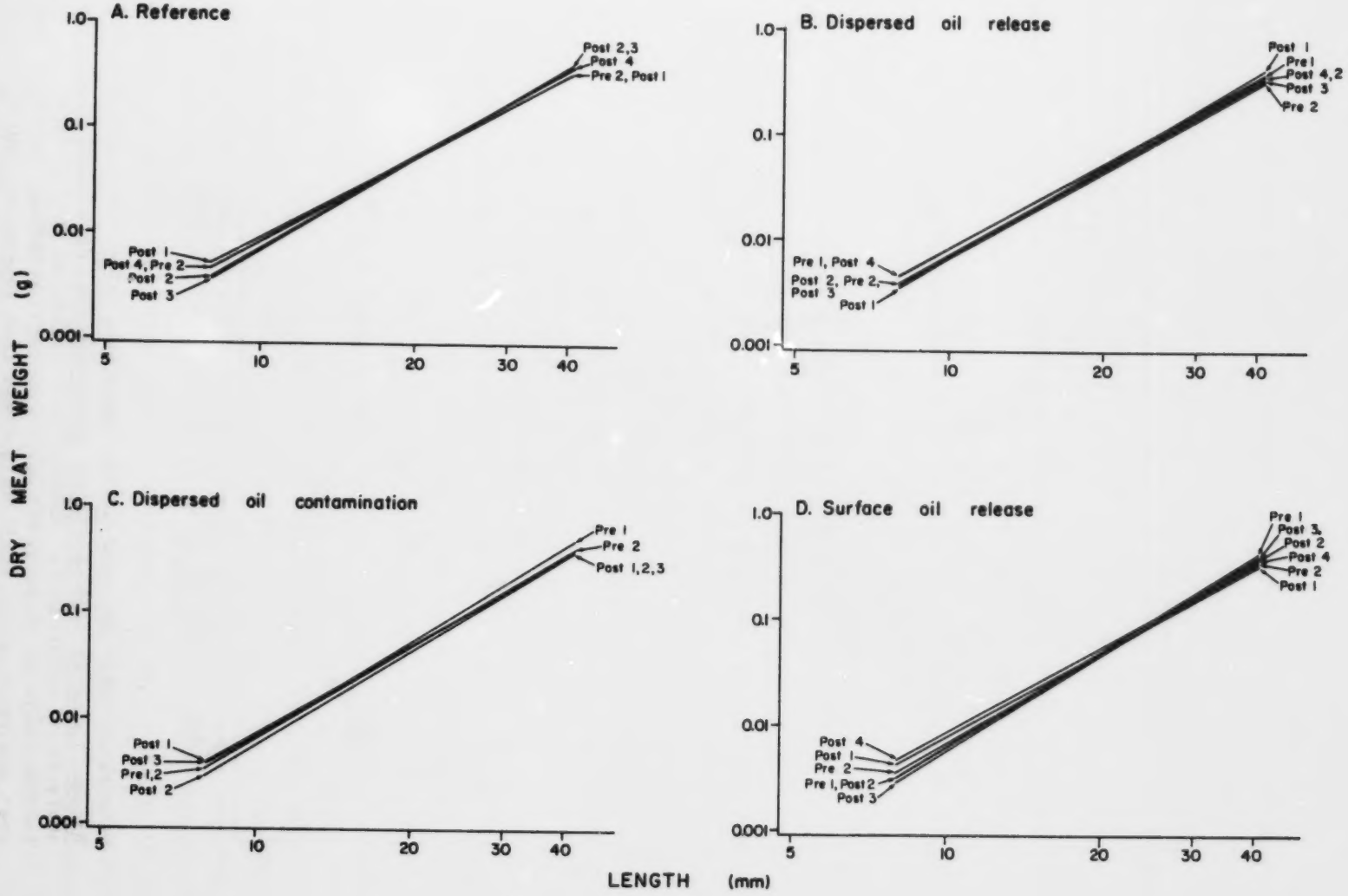


Figure 14. Least square regression lines of dry meat weight vs. length for Astarte borealis in four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in September 1980 and August 1981, and during post-spill sampling in September 1981, August and September 1982, and August 1983.

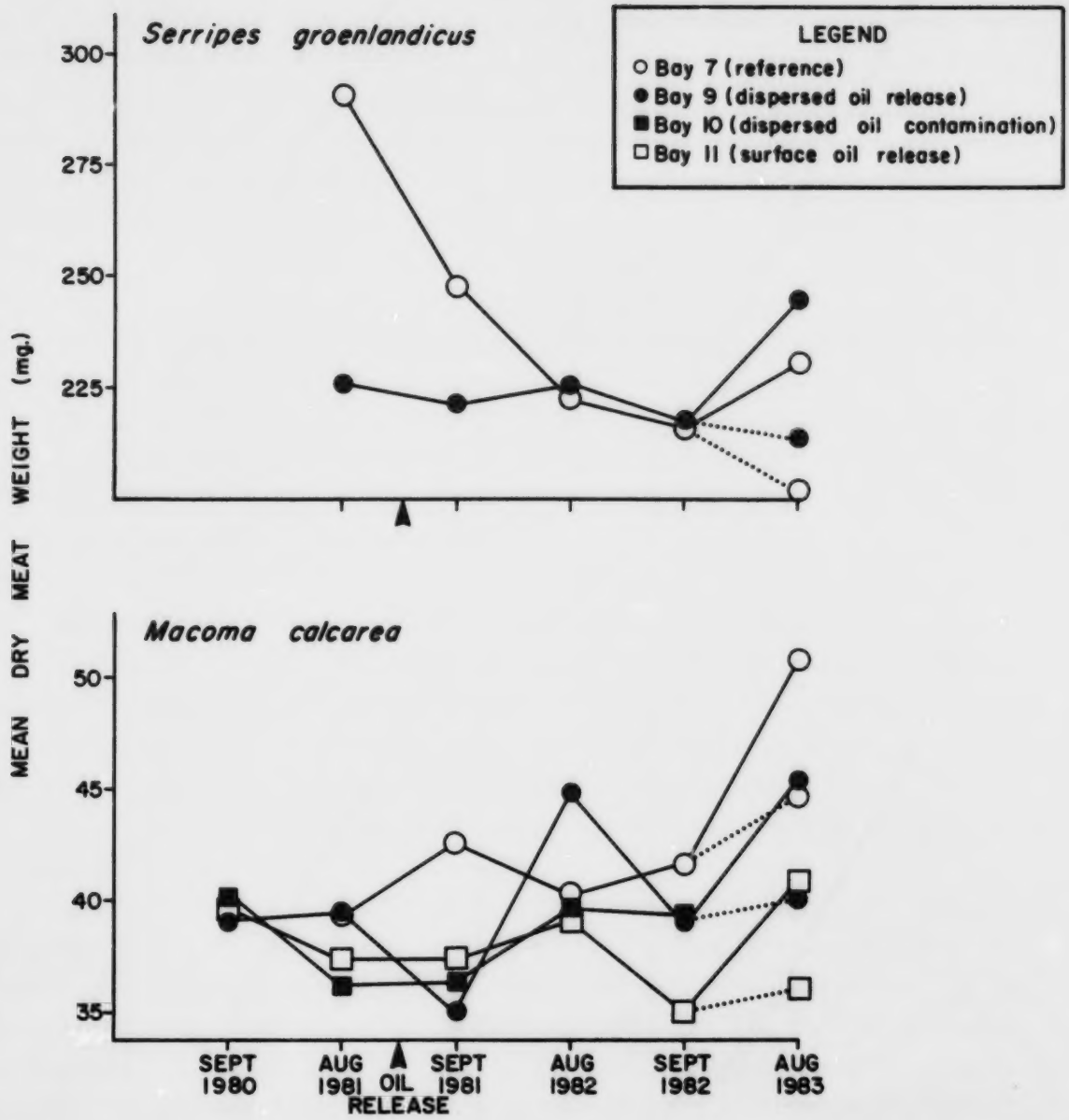


Figure 15. Backtransformed adjusted group mean dry meat weights of Macoma calcarea and Serripes groenlandicus determined in analysis of covariance. Animals were collected at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post- spill sampling periods from September 1980 to August 1983. Dotted lines show estimated correction for alcohol weight loss (see text).

Section 3.1.3.b). In Bay 7, adjusted dry meat weight of M. calcarea increased between August and September in 1981 and 1982. In contrast, in both 1981 and 1982, adjusted mean dry weight decreased from August to September in Bay 9 and was relatively constant in Bay 10 (Fig. 15). Between August and September in Bay 11, weight was constant in 1981, and decreased in 1982.

The increase in body tissue relative to length in Bay 7 likely represented a natural seasonal increase in storage materials, which are necessary to meet metabolic requirements in winter. Increase in length in Macoma balthica apparently ceases during winter in temperate, boreal and arctic waters (Green 1973; Buekema and de Bruin 1977; Chambers and Milne 1979; Bachelet 1980). In the Dutch Wadden Sea (Buekema and de Bruin 1977), M. balthica increased in length and tissue weight from March to June; in the subsequent 8-9 months length remained constant, whereas almost two-thirds of the summer's increase in dry tissue weight was lost. Thus the observed seasonal increase in weight relative to length in the reference bay in both 1981 and 1982 is to be expected. The lack of such an effect or its reversal in the other (oiled) bays may be attributable to oil effects on feeding or metabolic processes. Macoma spp. consume deposited organic matter with the inhalent siphon (Ockelmann 1958), and oil concentrations between 275 and 800 µg/g were concentrated by M. calcarea in Bays 9, 10 and 11 in the two weeks following the oil release (Boehm 1983). Oil has been reported to interfere with feeding behaviour (Atema and Stein 1974; Atema 1976; Hyland and Miller 1979; Augenfeld 1980) and to increase metabolic rate (Hargrave and Newcombe 1973; Fong 1976).

Inspection of the adjusted dry meat weights for Serripes groenlandicus in each period and bay shows unexpected results (Fig. 15). Results for Bays 10 and 11 are not included, because too few individuals were measured (5-20 per sampling period). In Bay 9 (n = 28-45 per period), differences in weights among periods were small. However, in Bay 7 (n = 19-33) the among-period differences were considerable. The significant period x bay interaction must be interpreted as an oil effect in this case because, in Bay 7, bivalves showed a progressive decrease in adjusted mean dry weight from the second pre-spill to the third post-spill period (Fig. 15). If the

same correction for length of time in alcohol calculated for Macoma calcarea is applied, the decrease continued until August 1983. The decrease in weights in Bay 7 was unexpected because Bay 7, the reference bay, received very low concentrations of dispersed oil. However, the body burdens of hydrocarbons in S. groenlandicus immediately following the dispersed oil release were highest in this bay (Boehm 1983).

It was suggested by Boehm et al. (1982) that Serripes groenlandicus were narcotized or killed by the high levels of dispersed oil in Bay 9, whereas in Bay 7 they continued to filter water and accumulate oil for several days following the dispersed oil release. In experiments designed to simulate conditions during the release in Bay 9, and carried out in aquaria at the Cape Hatt site, ostial closure (indicating reduced filtration of water) occurred in 50% of the test animals after 1/2 h, and recovery was not evident for 3-5 days (Engelhardt et al. 1983). Clement et al. (1980) also found that the ability of Macoma balthica to concentrate Prudhoe Bay crude oil from seawater dispersions increased with decreasing oil concentrations, probably as a result of reduced siphon activity at high oil concentrations.

In summary, weight-length relationships in two of the four bivalve species examined were apparently affected by the experimental oil releases at Cape Hatt. In Macoma calcarea, the normal seasonal (August to September) increase in tissue weight relative to length occurred only in the reference bay. Macoma calcarea is a deposit feeder, and high concentrations of oil were accumulated in its body tissues from sediments in the oiled bays during the two weeks following the oil releases. In Serripes groenlandicus, tissue weight adjusted for length decreased progressively in the reference bay following the dispersed oil release. Serripes groenlandicus accumulated more oil in this bay than in any other, probably because its filtering activity was not impaired as it was in bays where dispersed oil concentrations were high. Thus it appears that the weight-length relationship in the deposit-feeding M. calcarea was affected by high oil concentrations in sediments, whereas that in the filter-feeding S. groenlandicus was affected by low oil concentrations in the water.

3.4.6 Community Structure

Perturbation of the benthic marine environment often results in large-scale changes in infaunal community structure (Pearson and Rosenberg 1978). Faunal changes resulting from the introduction of oil may be drastic and the degree of change is related to the intensity and duration of oiling (Sanders et al. 1980). One of the best approaches for detecting oil effects appears to be the community or ecosystem approach (Mann and Clark 1978; Elmgren et al. 1980).

We are using changes in benthic community structure as a test of oil effects in the experimental bays at Cape Hatt. The term community, in these tests, refers to assemblages of benthic animals that occur together. Since distribution of benthic animals may be affected by currents, food availability, substrate and depth, similar assemblages of animals may be found under similar environmental conditions. The study bays at Cape Hatt were selected on the basis of similarity of infauna. At 7 m depth the infauna found in all of the bays was, in a qualitative sense, representative of a typical high arctic Macoma community. We have used factor analysis to identify assemblages within this community and to detect differences among the study bays and sampling periods.

Either density or biomass data would be adequate for the detection of large-scale change, but subtle faunal changes would be more readily detected in density data. The biomass data are dominated by the presence and abundance of older individuals and are relatively insensitive to numerical changes in younger individuals. Hence analyses were performed on density data.

The species considered in analyses of community structure were those that accounted for 0.9% or more of total infaunal numbers at each depth. In this way 21 taxa representing 85% of total numbers at the 3 m depth and 23 taxa representing 82% of total numbers at the 7 m depth were selected for factor analyses. Thus, at each depth, analyses considered all of the common species and over 80% of the total numbers of infauna.

The results of the factor analyses applied to the most common species collected at 3 and 7 m depths during all sampling periods and from all bays are summarized in Tables 10 and 11, respectively. At 3 m depth, five factors accounted for 65.1% of the variance represented by the 21 species variables. At 7 m depth, six factors accounted for 59.0% of the variance represented by the 23 species variables. Each of these factors represents an assemblage of species that tend to occur together and whose densities vary more or less proportionately. Tables 10 and 11 list the species whose densities were strongly correlated with each of the factors. Some factors also represent certain species (those with negative signs) that tend to be absent or rare at locations where the the other species are common.

The mean abundance (factor score) of each of these assemblages (factors) for each period/bay combination is presented in Figure 16 (3 m depth) and 17 (7 m depth). It should be noted that it is relative abundance that is depicted in these figures. For example, at 3 m depth the first factor (assemblage), representing primarily the species listed under Factor 1 in Table 10, was more strongly represented in Bays 9 and 10 than in Bays 7 and 11; it was not necessarily absent in the latter two bays (Fig. 16).

Differences in community composition among bays and periods were assessed with multivariate analyses of variance using, as dependent variables, the factor scores for each of the factors derived in the previous analyses. These analyses test for differences in community composition among bays and periods by simultaneously considering the scores for all factors. Since these factors, in turn, represent assemblages of the most common species, the analyses test for departures from the 'average' community composition. The results of these analyses, together with (univariate) analyses of variance for each assemblage (factor), are given in Appendices L to N, and are summarized in Table 12.

3.4.6.a Spatial Effects

Most of the significant ($P<0.05$) variation in all analyses was spatial, including both variation among transects within bays and variation among bays. Variation among transects was significant at both depths according to all multivariate analyses, and at 3 m depth according to all univariate

Table 10. Results of factor analysis of the 21 benthic animals that each represented 0.9% or more of total infaunal numbers collected at 3 m depth at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983. The values shown are the correlations between the log-transformed densities of various species (the original variables) and each of the five factors determined in the analysis. Species whose densities were weakly correlated with a factor ($-0.4 < r < 0.4$) are not shown. Also shown is the variance explained by each factor, expressed as a percentage of the variance of the original variables.

1. Variance explained	20.4%
Astarte juveniles	0.849
Thyasiridae spp.	0.779
Mya truncata	0.742
Tharyx marioni	0.636
Astarte borealis	0.612
Chaetozone setosa	0.533
Astarte montagui	0.532
Euchone analis	0.518
Cingula castanea	0.482
Retusa obtusa	0.413

2. Variance explained	17.3%
Myriotrochus rinkii	0.790
Pholoe minuta	0.743
Asabellides sibirica	0.686
Retusa obtusa	0.534
Cingula castanea	0.524
Astarte montagui	0.523
Astarte borealis	0.520
Euchone analis	0.454
Mya truncata	0.425

3. Variance explained	11.5%
Musculus discors	0.870
Musculus juveniles	0.814
Nereimyra punctata	0.681
Harmothoe imbricata	0.418

4. Variance explained	8.4%
Spio spp.	0.712
Capitella capitata	0.600
Harmothoe imbricata	-0.631

5. Variance explained	7.5%
Mediomastus spp.	0.714
Eteone longa	0.617
Chaetozone setosa	0.582

Table 11. Results of factor analysis of the 23 benthic animals that each represented 0.9% or more of total infaunal numbers collected at 7 m depth at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983. The values shown are the correlations between the log-transformed densities of various species (the original variables) and each of the six factors determined in the analysis. Species whose densities were weakly correlated with a factor ($-0.4 < r < 0.4$) are not shown. Also shown is the variance explained by each factor expressed as a percentage of the variance of the original variables.

1. Variance explained	14.3%
Astarte montagui	0.857
Astarte borealis	0.806
Astarte juveniles	0.776
Nuculana minuta	0.509
Mya truncata	0.496
Praxillella praetermissa	0.493
Maldane sarsi	0.405

2. Variance explained	11.5%
Thyasiridae spp.	0.847
Macoma calcarea	0.801
Macoma juveniles	0.537
Serripes groenlandicus	0.432
Nuculana minuta	0.406

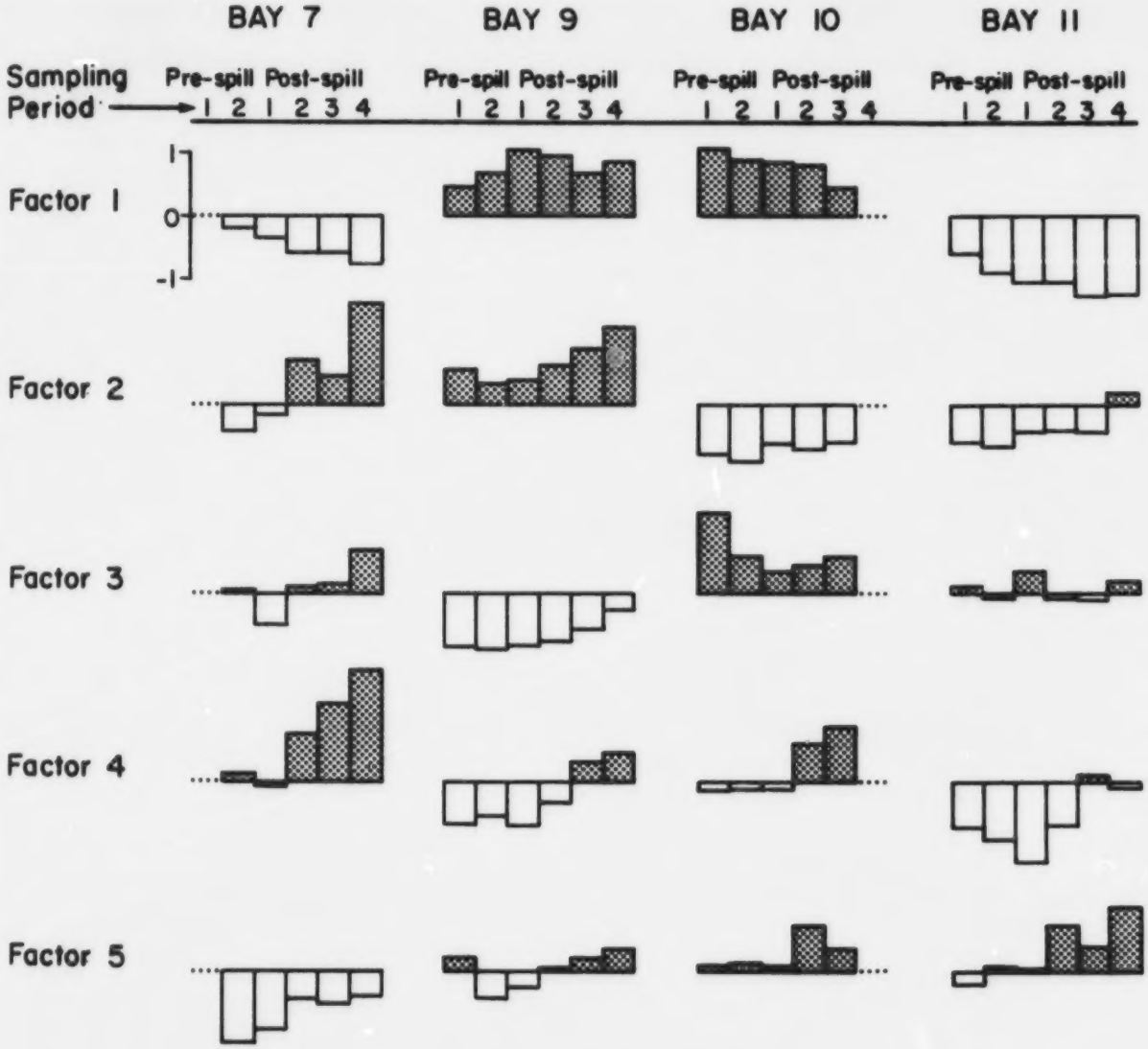
3. Variance explained	10.7%
Musculus juveniles	0.727
Musculus niger	0.699
Serripes groenlandicus	0.634
Retusa obtusa	0.453
Cingula castanea	0.450

4. Variance explained	9.3%
Spio spp.	0.768
Mediomastus sp.	0.704
Pholoe minuta	0.599
Capitella capitata	0.569

5. Variance explained	7.7%
Moellaria costulata	0.773
Trichotropis borealis	0.483
Cingula castanea	0.474
Scoloplos armiger	-0.468

6. Variance explained	5.5%
Pectinaria granulata	0.788
Maldane sarsi	-0.415

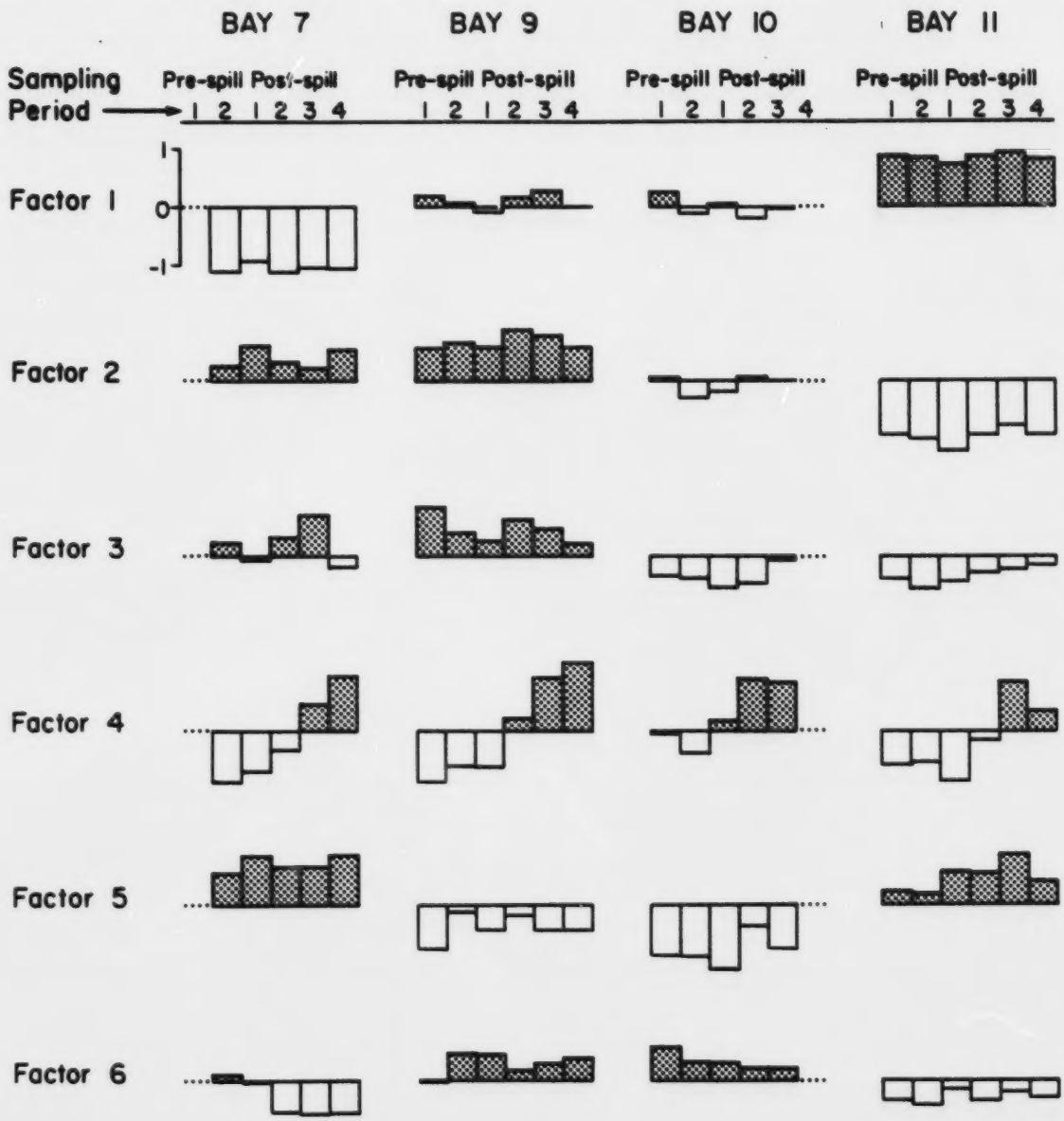
Figure 16. Mean factor scores for each period and bay at 3 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2].



[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), and Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

Figure 17. Mean factor scores for each period and bay at 7 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2].



[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), and Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

Table 12. Summary of multivariate and univariate analyses of variance (MANOVA and ANOVA) for factor scores determined in factor analyses of infaunal density in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. Significance levels (ns = $P>0.05$; * $P\leq0.05$; ** $P\leq0.01$; *** $P\leq0.001$) are shown for three analysis types[3]; a single value indicates that results of all three analysis types were consistent.

		Source of Variation				
Depth	Variable	Period	Bay	Period x Bay[5]	Transect (Bay)[4]	Per x Trans (Bay)[4]
3 m	**MANOVA**					
	Pillai's trace	***/***/ns	***	ns	***	ns/ns/*
	ANOVAS					
	Factor 1	ns	***	ns	***	ns
	Factor 2	ns/ns/***	***	ns	***	ns
	Factor 3	ns/ns/*	***	ns	***	ns
	Factor 4	***	***	ns	***	ns
	Factor 5	ns/**/***	ns/***/***	ns	***	ns
7 m	**MANOVA**					
	Pillai's trace	**	***	ns	***	ns
	ANOVAS					
	Factor 1	ns	***	ns	ns	ns
	Factor 2	ns	***	ns	**/***/***	ns
	Factor 3	ns	***	ns	***	ns
	Factor 4	6/***/***	6/***/ns	*/ns/ns	**/ns/*	ns
	Factor 5	*/ns/ns	***	ns	ns/*/*	ns
	Factor 6	ns	**	ns	***	ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

[3] Results are shown for analyses involving (1) Bays 9, 10, 11 in 1980-1982, (2) Bays 7, 9, 10, 11 in 1981 and 1982, (3) Bays 7, 9, 11 in 1981-1983; detailed ANOVA results are given in Appendices L to N.

[4] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant ($P\leq0.05$), Transect (Bay) alone was used to test main effects.

[5] The Period x Bay term is the test of oil effects.

[6] Interpretation of main effects confounded by significant interaction of Period x Bay term.

analyses of assemblages. At 7 m depth, only the first assemblage (bivalves and maldanid polychaetes) occurred in similar abundances on the three transects in each bay and sampling period (Table 12). Another two assemblages, including gastropods and small polychaetes, showed some evidence of even distributions on the 50 m (transect) scale. These results indicate a patchy distribution of most infaunal assemblages on the 50 m scale at both depths. However, the lack of significant period x transect interactions shows that all within-bay differences at both depths were consistent over time (Table 12). That is, abundances on particular transects were consistently high or low over the four years of sampling.

At each depth, **among-bay variability** was evident for the community as a whole (i.e. in all multivariate analyses), and also for all individual assemblages (Table 12). At each depth, one assemblage showed among-bay differences in only one or two of three analysis types; at each depth this assemblage consisted of small polychaetes. Inspection of the data (Figs. 16 and 17), together with the conflicting test results (Table 12), indicates that these assemblages occurred in similar abundances in three of the four study bays.

At both depths, spatial distributions differed markedly among the various assemblages (Figs. 16 and 17). For example, at 3 m depth Factor 1 was best represented in Bays 9 (dispersed oil release) and 10 (dispersed oil contamination), Factor 4 was most strongly associated with Bay 7 (reference) and Factor 5 with Bay 11 (surface oil release).

Overall among-bay differences in community structure are illustrated in the graphical representation of the results of the multivariate analyses (Figs. 18 and 19). In these figures, distances between points represent differences in community structure. At 7 m depth, the benthic community in each bay changed relatively little across sampling periods, in comparison with the greater differences among bays. Infaunal communities in Bays 7, 9 and 10 were more similar to each other than any bay was to Bay 11 (Fig. 18). At 3 m depth, differences among bays, and in particular among Bays 7, 9 and 10, were not as pronounced as at 7 m depth (compare Figs. 18 and 19).

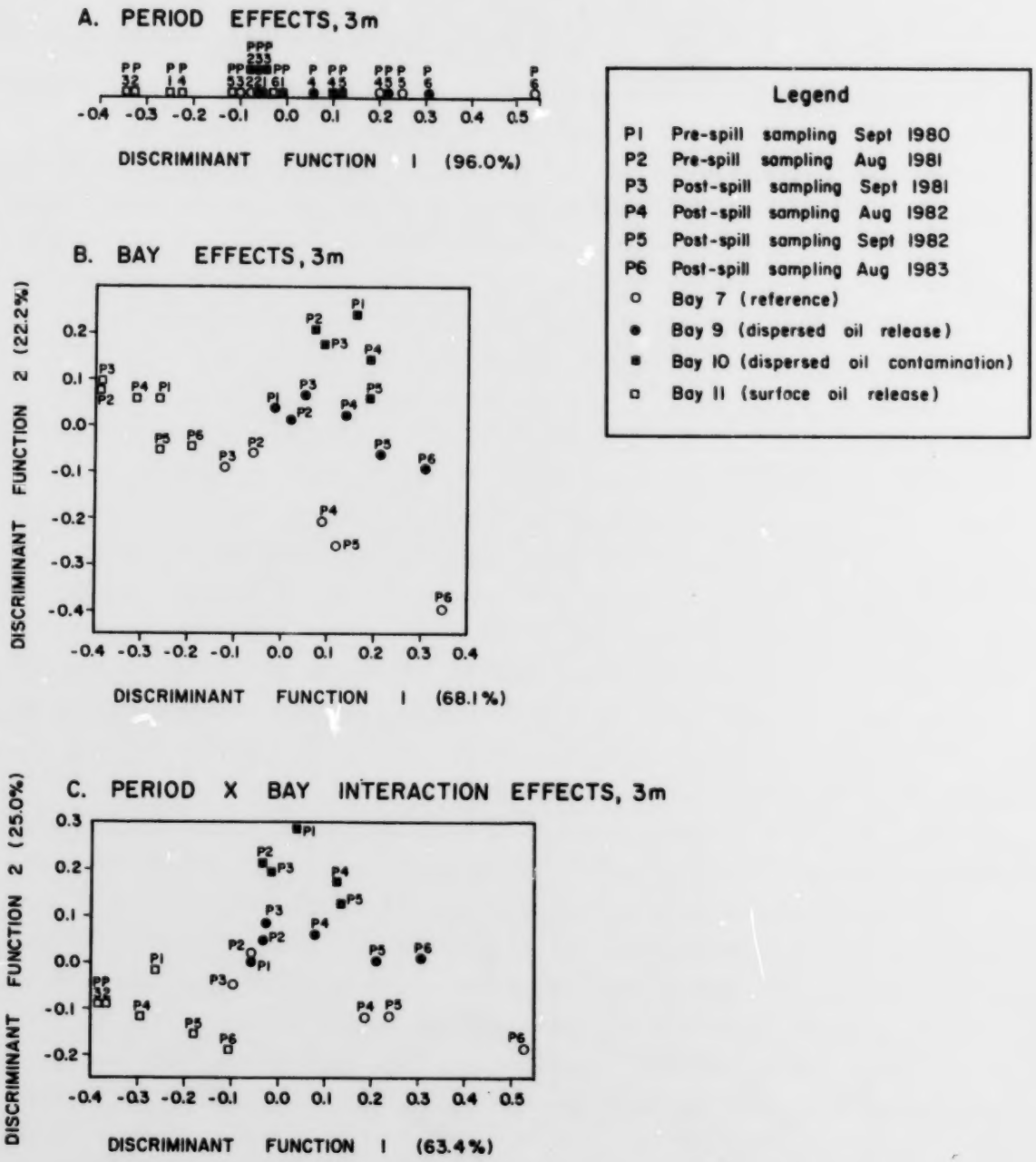

A. PERIOD EFFECTS, 3m
DISCRIMINANT FUNCTION 1 (96.0%)
B. BAY EFFECTS, 3m
DISCRIMINANT FUNCTION 2 (22.2%)
DISCRIMINANT FUNCTION 1 (68.1%)
C. PERIOD X BAY INTERACTION EFFECTS, 3m
DISCRIMINANT FUNCTION 2 (25.0%)
DISCRIMINANT FUNCTION 1 (63.4%)
Legend
P1 Pre-spill sampling Sept 1980
P2 Pre-spill sampling Aug 1981
P3 Post-spill sampling Sept 1981
P4 Post-spill sampling Aug 1982
P5 Post-spill sampling Sept 1982
P6 Post-spill sampling Aug 1983
Bay 7 (reference)
Bay 9 (dispersed oil release)
Bay 10 (dispersed oil contamination)
Bay 11 (surface oil release)

Figure 18. Graphical representation of results in multivariate analysis of variance using data collected at 3 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. The plots display the results of the tests for main effects and interactions using the transect term as the error term.

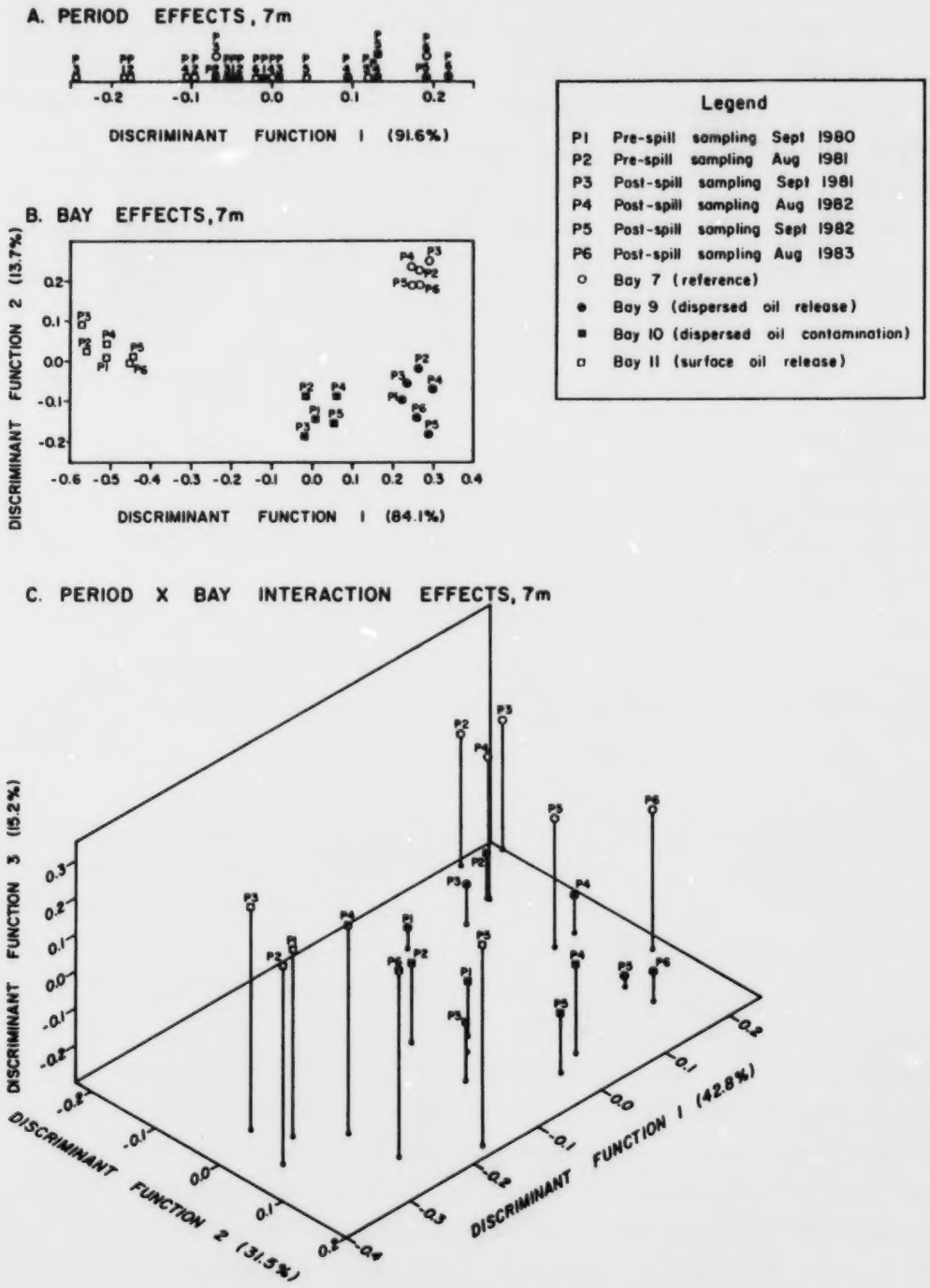


Figure 19. Graphical representation of results in multivariate analysis of variance using data collected at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. The plots display the results of the tests for main effects and interactions using the transect term as the error term.

3.4.6.b Temporal Effects

At both depths, the multivariate analyses showed significant temporal variability in community structure. However, temporal variability appeared to be a less important component of variability in community structure than did spatial variability, particularly at 7 m depth (Table 12). The graphical representations of the temporal effects (Figs. 18 and 19) confirm that temporal differences were not nearly as well defined as were bay effects.

At 3 m depth, results of analyses for the various assemblages showed considerable inconsistencies among analysis types and among assemblages. Only about half of the tests showed significant variability in abundance over time (Table 12). Only the first assemblage, mainly representing five bivalves, three polychaetes and two gastropods, did not vary in abundance over the four years of study according to any method of analysis. The second and third assemblages, each also representing certain bivalves and polychaetes, showed variability among sampling periods only when 1983 data were included. In these cases most of the temporal change consisted of increases in relative abundance through time (Fig. 18). The same was true for the last two assemblages, each representing three polychaete species.

At 7 m depth, only the fourth assemblage, mainly representing small polychaetes, showed marked temporal variation. Temporal differences in the abundance of this assemblage appeared greater than did differences among bays (Fig. 17). The abundance of this assemblage increased over the four years of sampling. This was the only assemblage at 7 m depth whose temporal changes in abundance were relatively consistent among bays (Fig. 17). The abundance of the fifth assemblage (three gastropods and an errant polychaete) differed among sampling periods only when the 1980 data were included in the analyses (Table 12); in this instance, bay differences appeared to be much larger than period differences (Fig. 17).

3.4.6.c Oil Effects

In the present study, effects of oil or dispersed oil on community structure would be evident as pre- to post-spill changes that occurred (1) in the dispersed oil bay(s) and not in the surface oil bay, or (2) in the

experimental bays and not in the reference bay. Such effects would appear as a significant period x bay interaction term. This term was not significant in multivariate analysis of variance at either depth (Table 12).

Univariate analyses were carried out for abundances (factor scores) of five species assemblages at 3 m depth and six assemblages at 7 m depth. Bay x period interaction effects were significant for only one assemblage (the fourth assemblage at 7 m depth), and only in one type of analysis (that which considered only Bays 9, 10 and 11 and the 1980, 1981 and 1982 sampling periods). This assemblage consisted mainly of the small polychaetes Spio spp., Mediomastus sp., Pholoe minuta and Capitella capitata (Table 11). In general, its abundance increased progressively throughout the study period (Fig. 17). Inspection of the data indicated that one possible source of the observed interaction was larger negative factor scores in Bays 9 and 11 than in Bay 10 during September 1980 (Pre-spill Period 1); this clearly does not represent an oil effect. In general, the pre- to post-spill change that was not consistent among bays appeared to be an earlier, but less pronounced, relative increase in the abundance of this factor in Bay 10 than in Bays 9 or 11. This might be indicative of an oil effect, except that the clearest increase of all in the abundance of this assemblage occurred in the reference bay (Fig. 17). Therefore, the significant interaction term for the fourth assemblage at 7 m depth did not represent an oil effect.

Thus, oil and dispersed oil did not seem to affect community composition or the abundances of dominant species assemblages. This conclusion is based on data collected 1 year and 2-4 weeks before the oil releases as compared to 2-4 weeks, 1 year and 2 years after the oil releases.

The graphical representations of these interaction terms in Figures 18 and 19 show that the relative locations of periods within bays are quite similar for the four bays, and that the relative locations of bays within periods are similar for the various periods. At both depths and in each bay, community structure in the first three or four sampling periods was similar; the points representing these bay-period combinations form one grouping for each bay. The last two or three sampling periods within each bay also tend to be grouped together (Figs. 18 and 19).

Another representation of the similarities and differences in benthic community structure in various bays and periods is shown in Figures 20 and 21. In this cluster analysis, bay-period combinations that were most similar on the basis of the animal assemblages present were joined together to form clusters. Bay-period combinations were added to clusters in decreasing order of similarity of the animal assemblages present.

At 7 m depth, Bays 9 and 10 were the most similar in terms of animals present, and Bay 11 was the most distinct. At 3 m depth, no two bays appeared to be any more similar than any other bays. At both depths, the period groupings were similar for all bays. Animals present during the two pre-spill sampling periods and the first post-spill sampling period tended to be similar, and therefore formed one cluster. A second cluster was formed by the last two or three post-spill periods.

Thus two different types of analysis of the differences and similarities in infaunal community structure among bays and sampling periods (multivariate analysis of variance and cluster analysis) gave very similar results. Infaunal community structure in the study area changed during the four years of study, but this temporal change was similar in each bay and at both depths studied. The interval of greatest change was at some time between September 1981 and September 1982. However, the generally parallel trends in all bays indicate that this change in community structure was not related to the different oil treatments (surface vs. dispersed) or to the observed differences in the levels of dispersed oil contamination or of oil concentrations in sediments in the various study bays.

3.4.7 Feeding Guilds

An animal's mode of feeding may determine its degree of exposure to oil. A short exposure to dispersed oil may not affect filter feeders as they may stop feeding temporarily. The resultant oil-containing flocs that accumulate on the surface of the sediment may, however, seriously affect surface deposit feeders. In active benthic environments, wave action and sediment transport may incorporate undispersed oil into the sediment and seriously affect burrowing deposit feeders. Thus, it is appropriate to

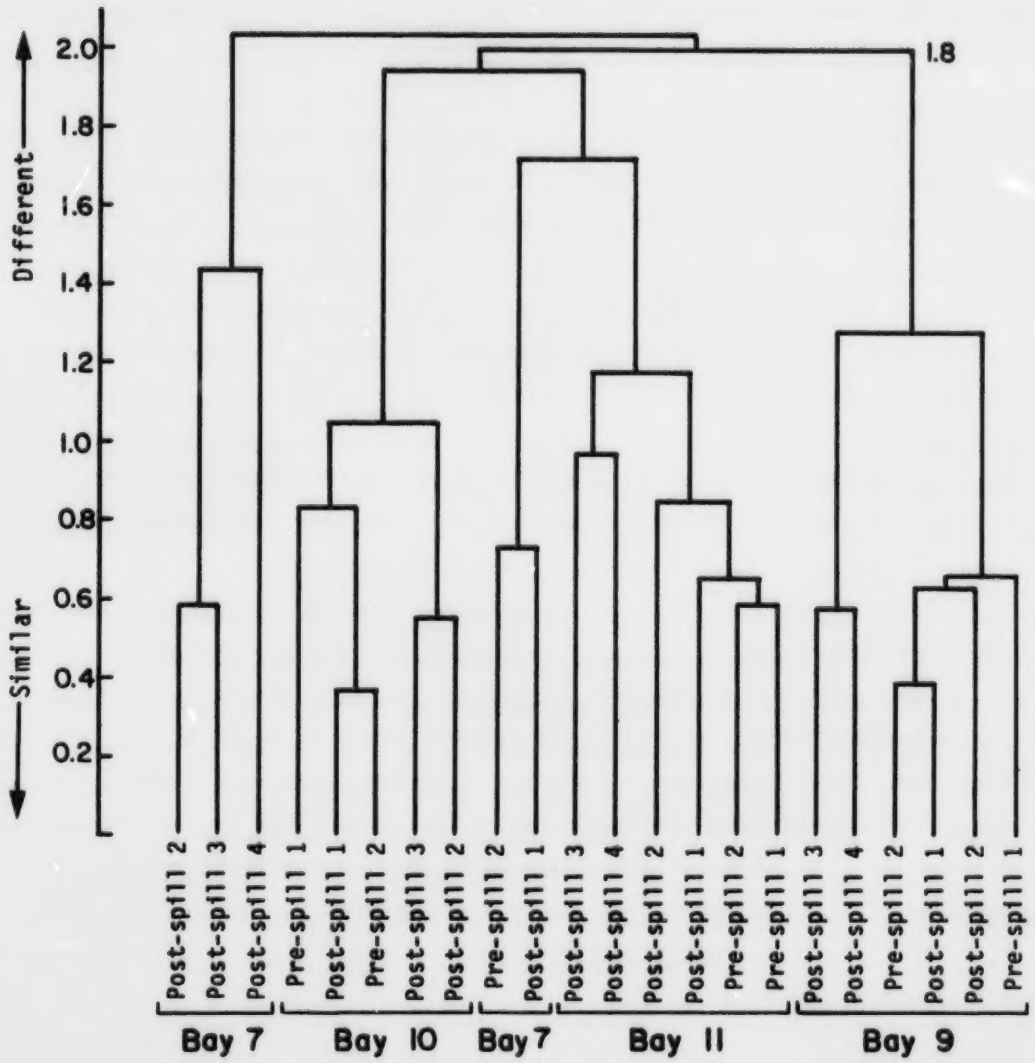


Figure 20. Dendrogram showing the similarity of infaunal assemblages at 3 m depth in four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in September 1980 and August 1981, and during post-spill sampling in September 1981, August and September 1982, and August 1983.

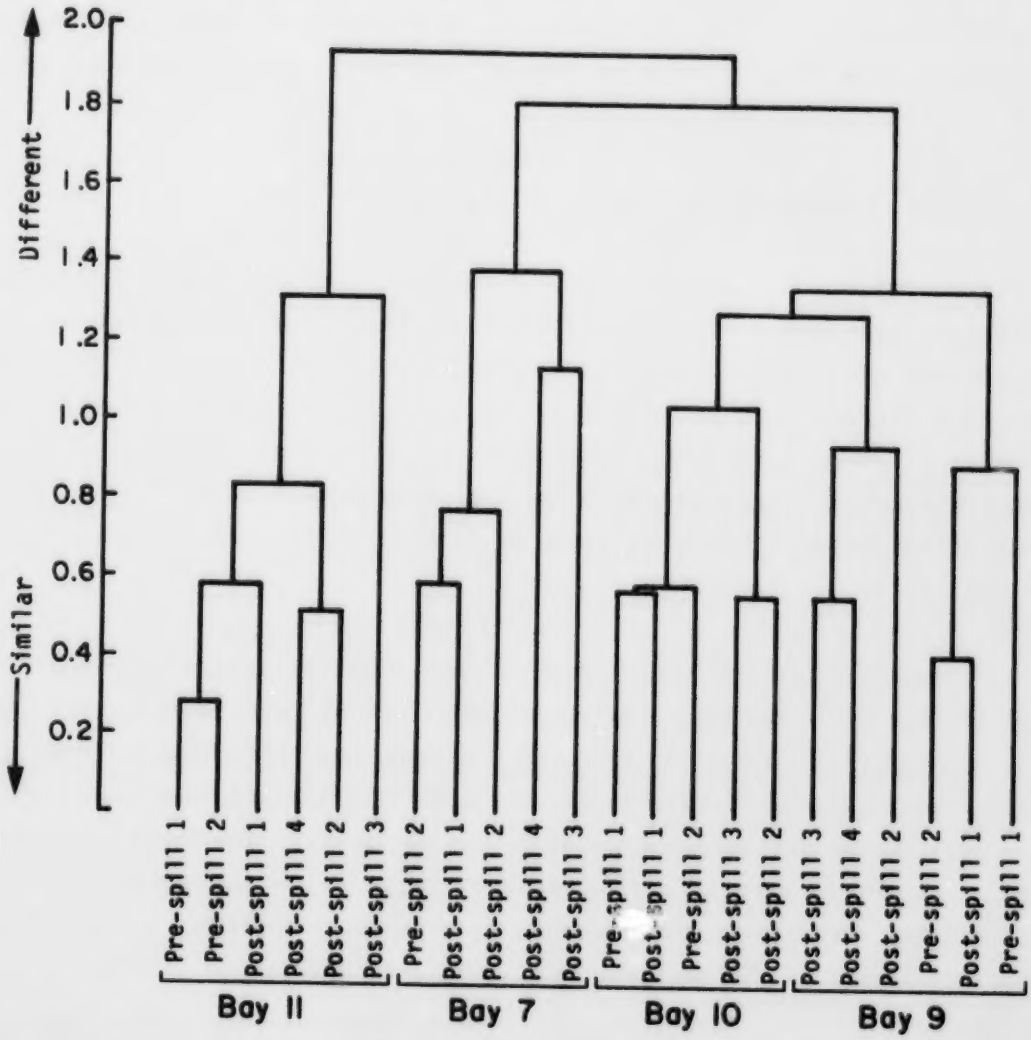


Figure 21. Dendrogram showing the similarity of infaunal assemblages at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre-spill sampling in September 1980 and August 1981, and during post-spill sampling in September 1981, August and September 1982, and August 1983.

categorize the animals by feeding guild and analyze the effects of the oil treatments on the various guilds.

The infaunal animals (excluding gastropods) collected by the airlift sampler were classified into four feeding guilds based on data available in the literature (Table 13). The feeding modes follow those described by Fauchald and Jumars (1979). The biomass in each sample was apportioned among those four guilds to provide a measure of abundance of each guild in each sample.

3.4.7.a Feeding Guilds Present at Cape Hatt

Filter feeders extract particulate material from the water. Sabellid polychaetes feed externally using a brachial 'fan', whereas bivalves pump water through their mantle cavity and remove particulate material with their gills. Mya truncata burrows deeply in the sediment and extends a siphon to the surface. Mussels (Musculus sp.) are usually attached to rocks or algae and filter material from water entering through a gape in their shell. Many benthic filter feeders ingest material of benthic rather than pelagic origin (Marshall 1970).

Some deposit feeders ingest sand or mud directly from the substrate. These include tube-dwellers (maldanid polychaetes) and polychaetes that burrow through the mud such as Capitella capitata (Fauchald and Jumars 1979). Deposit feeders derive their nutrition from bacteria associated with the organic matter and detritus found in the sediments. The deposit feeders listed in Table 13 generally feed at some depth below the surface of the sediment. The activity of these animals is especially important in reworking the surface layers of the sediment (e.g., Cadée 1979).

Surface deposit feeders feed at the sediment-water interface. Their food includes benthic microalgae and bacteria. Most of the polychaetes included in this group (Table 13) feed by means of tentacles (Fauchald and Jumars 1979). The bivalve Nuculana minuta extends a pair of tentacles over the surface of the sediment (Ansell and Parulekar 1978); the bivalve Macoma calcarea draws in fine particulate material from the sediment surface with an inhalant siphon (Reid and Reid 1969).

Table 13. Feeding mode of benthic infaunal animals (excluding gastropods) from Cape Hatt, northern Baffin Island.

	Polychaetes	Bivalves	Others
Carnivores	Phyllodocidae Polynoidae Sigalionidae Hesionidae Syllidae Glyceridae Nephtyidae Lumbrineridae		Nemertea Priapulida
Deposit Feeders	Orbiniidae Capitellidae Maldanidae Opheliidae Scalibregmidae Nereidae Pectinaridae		Sipuncula Holothuroidea
Surface Deposit Feeders	Paraonidae Spionidae Cirratulidae Sphaerodoridae Oweniidae Flabelligeridae Ampharetidae Terebellidae Trichobranchidae	Nuculidae Nuculanidae Tellinidae	Echiura Ophiuroidea Echinoidea
Filter Feeders	Sabellidae Spirorbidae	Mytilidae Thyasiridae Astartidae Cardiidae Myidae Hiatellidae Lyonsiidae Thraciidae	Acidiacea

References for feeding type: Ockelmann 1958; Reid and Reid 1969; Himmelman and Steele 1971; Barnes 1974; Ansell and Parulekar 1978; Mohlenberg and Riisgard 1978; Fauchald and Jumars 1979.

The carnivores listed in Table 13 are all motile predators.

At Cape Hatt, filter feeding was the dominant feeding mode in every combination of depth, bay and period (49.1 to 92.6% of infaunal biomass; Table 14). Surface deposit feeding was the second most common mode of feeding at 7 m depth (5.7 to 24.3% of infaunal biomass), and the least common at 3 m depth (0.7 to 13.9%). Depth differences may be a result of greater instability of the sediment surface in shallow water due to wave action. Deposit feeders and carnivores comprised similar and intermediate percentages of infaunal biomass at 3 m depth (1.7 to 27.1%). At 7 m depth these two feeding guilds were less abundant than either of the other guilds (Table 14).

3.4.7.b Spatial Variation at 3 m Depth

At this depth there was considerable small scale variation (50 m or transect scale) in the biomass of each of the four feeding guilds in the study bays (Table 15). However, in almost every case the among-transect variability was consistent over time (i.e. little or no period x transect interaction--Table 15). Large scale spatial variability (among bays) was also evident; only the biomass of carnivores was similar in all of the bays (Table 15; Fig. 22).

In general, the three feeding guilds whose biomasses differed between bays at 3 m depth were most abundant in Bay 9 (dispersed oil release) and least abundant in Bay 11 (surface oil release). The differences were best defined in the case of filter feeders (Fig. 22; Appendix O). The overwhelming dominance of infaunal biomass by filter feeders, primarily the bivalve Mya truncata, is evident in a comparison of data for biomass of total infauna (Fig. 5), total bivalves and M. truncata (Fig. 6), and filter feeders (Fig. 22), which are all remarkably similar.

Differences among bays in biomass of filter feeders at 3 m depth may be a function of the location of the 3 m transects in relation to the boundary between the barren zone and the zone of dense infauna. A layer of freshened water was observed to extend to the 3 m transects in all study bays. However, specific features of Bays 9 and 11 may have resulted in differences

Table 14. Percent contribution to total infaunal biomass[1] by major feeding mode in four bays[2] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[3].

		3 m Depth				7 m Depth			
	Period	Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Carnivores	Pre-spill 1	-	3.3	4.0	9.9	-	0.7	1.2	1.2
	Pre-spill 2	10.7	2.0	3.1	18.9	2.0	1.7	2.7	2.1
	Post-spill 1	6.3	1.7	3.7	23.5	3.4	1.2	1.2	0.6
	Post-spill 2	6.9	1.8	2.7	13.5	2.7	1.7	0.6	2.3
	Post-spill 3	10.3	2.7	2.8	14.6	6.2	2.0	1.9	1.1
	Post-spill 4	4.3	2.2	-	19.6	2.9	2.7	-	2.0
Filter feeders	Pre-spill 1	-	88.7	86.0	67.7	-	90.9	89.4	86.0
	Pre-spill 2	76.8	89.2	87.8	60.3	70.9	80.9	84.0	88.8
	Post-spill 1	84.4	91.7	86.6	58.6	75.7	84.9	86.7	91.5
	Post-spill 2	82.4	92.6	86.3	75.4	74.9	84.7	85.0	89.6
	Post-spill 3	78.9	90.8	90.7	64.6	68.7	84.8	85.8	90.7
	Post-spill 4	77.5	92.2	-	49.1	74.4	85.5	-	90.0
Deposit feeders	Pre-spill 1	-	4.5	6.6	17.9	-	1.5	2.5	3.1
	Pre-spill 2	9.5	4.3	5.0	20.2	2.8	2.5	3.1	2.3
	Post-spill 1	4.8	3.1	4.6	13.9	2.5	2.1	2.5	2.1
	Post-spill 2	7.2	3.1	3.8	10.0	2.6	1.7	2.2	2.2
	Post-spill 3	6.8	2.9	3.1	13.6	4.0	2.2	2.7	1.9
	Post-spill 4	4.3	3.0	-	27.1	2.2	2.2	-	1.7
Surface deposit feeders	Pre-spill 1	-	3.6	3.4	4.4	-	6.9	6.9	9.8
	Pre-spill 2	3.0	4.5	4.0	0.7	24.3	14.9	10.1	6.8
	Post-spill 1	4.4	3.5	5.1	4.0	18.4	11.7	9.6	5.7
	Post-spill 2	3.5	2.5	7.2	1.1	19.8	11.9	12.1	5.9
	Post-spill 3	3.9	3.6	3.4	7.2	21.1	11.0	9.6	6.3
	Post-spill 4	13.9	2.6	-	4.2	20.5	9.6	-	6.3

[1] Wet weight including bivalve shells; does not include gastropods or other animals that were not classified into feeding guilds.
[2] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[3] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

Table 15. Summary of three-factor analyses of variance for biomass of animals according to feeding mode in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. Significance levels (ns = $P>0.05$; * $P\leq0.05$; ** $P\leq0.01$; *** $P<0.001$) are shown for three analysis types[3]; a single value indicates that results of all three analysis types were consistent.

		Source of Variation				
Depth	Feeding mode	Period	Bay	Period x Bay[4]	Transect (Bay)[5]	Per x Trans (Bay)[5]
3 m	Carnivores	ns	ns	ns	**/***/***	ns
	Filter feeders	ns	***	ns	***	ns
	Deposit feeders	ns/ns/*	***/**/***	ns	***/***/*	ns/*/ns
	Surface-deposit feeders	ns	***	ns	***	ns
7 m	Carnivores	ns	ns/*/ns	ns	ns/ns/**	ns
	Filter feeders	ns	**/***/***	ns	ns/**/**	ns
	Deposit feeders	ns	ns	ns	*/ns/ns	ns
	Surface-deposit feeders	ns	***	ns	ns	ns/*/*

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

3 Results are shown for analyses involving (1) Bays 9, 10, 11 in 1980-1982, (2) Bays 7, 9, 10, 11 in 1981 and 1982, and (3) Bays 7, 9, 11 in 1981-1983; detailed ANOVA results are given in Appendix P.

4 The Period x Bay term is the test of oil effects.

5 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant ($P\leq0.05$), Transect (Bay) alone was used to test main effects.

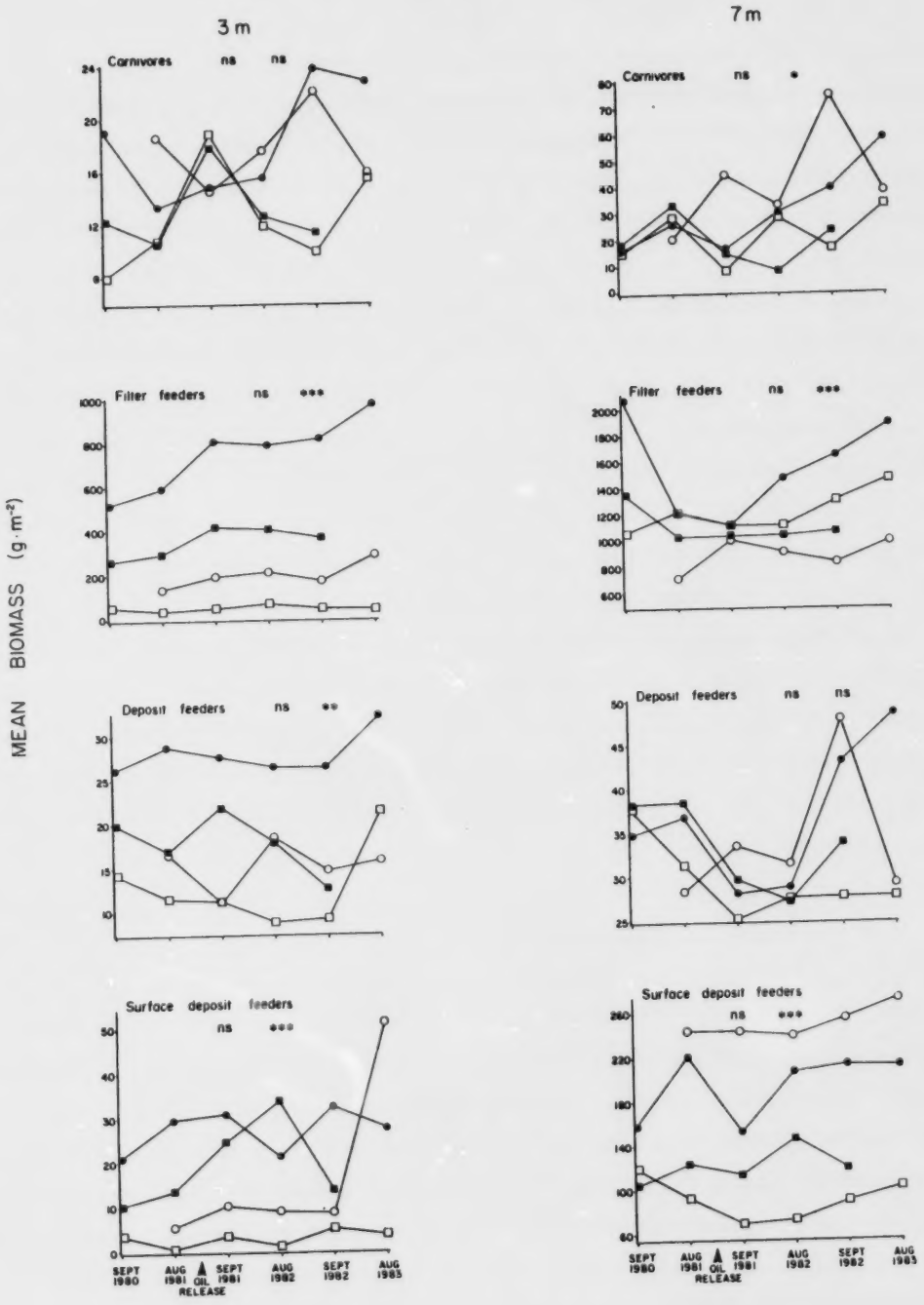


Figure 22. Mean biomass (g/m^2) of infaunal feeding guilds at 3 and 7 m depths in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples for each depth, bay and period, and significance levels are shown for period effects, followed by bay effects. Note that the ordinate does not always begin at zero. See Figure 23 for legend.

in amounts of suspended organic material or in salinity-related stress. Bay 11 is the most enclosed of the study bays. Hence, the layer of freshened water may have persisted longer there than in other bays. Bay 9 had the least apparent surface water run-off, and may, therefore, have been least affected by low salinity water.

Among-bay differences in biomasses of deposit feeders and surface deposit feeders may also be related to salinity differences, but the supply of food to deposit feeders would only be indirectly linked with water circulation or salinity. Deposit feeders ingest substrate and extract from it whatever nutritive value they can. The amount of organic matter or other characteristics of the substrate should then determine the distribution of these animals. The biomass of deposit feeders seemed unrelated to sediment characteristics (Table 2), likely because sediments were relatively similar in the study bays. There is an apparent relationship, however, between deposit feeders and organic matter. Total organic carbon in sediments was measured in Bays 9, 10 and 11 during 1980 (Green 1981); at 3 m depth the percentage of organic carbon was highest in Bay 9 (0.33%), intermediate in Bay 10 (0.21%) and lowest in Bay 11 (0.17%). Biomass of deposit feeders showed the same ranking of bays.

3.4.7.c Spatial Variation at 7 m Depth

At 7 m depth, biomasses of the various feeding guilds were more homogeneous on a small scale (50 m) than was true at 3 m depth. As was the case at the shallow depth, among-transect variability at 7 m was in most cases consistent over time (Table 15). Biomasses of filter feeders and surface deposit feeders at 7 m depth differed among bays, as was also true at 3 m depth. Biomasses of carnivores were similar or only marginally different among bays at both depths (Table 15). Deposit feeders at 7 m depth, unlike those in shallower water, occurred at similar biomasses in the four bays.

The relationship between biomass of deposit feeders and organic content was not as clear at 7 m depth as at 3 m depth, perhaps because among-bay variability in organic carbon content was less at 7 m (0.44, 0.39 and 0.62% in Bays 9, 10 and 11, respectively; Green 1981) than at 3 m depth (see

above). Sediment characteristics at 7 m depth were relatively similar in the study bays; in fact, gravel and sand fractions were somewhat more variable at 7 than at 3 m depth, in contrast to the distribution of deposit feeders. There does, however, appear to be a depth-related association between biomass of deposit feeders, sediment characteristics and organic content. In this region, a high organic content is associated with fine substrates (Thomson 1982). At Cape Hatt, sediments were finer, organic content was higher, and biomass of deposit feeders was higher at the deeper depth. Furthermore, within the study bays where depth differences in organic content were highest (Bays 10 and 11), depth differences in biomass of deposit feeders were also highest.

Surface deposit feeders show well defined among-bay differences in biomass at 7 m depth (Fig. 22). These animals feed on microalgae, detritus and bacteria at the sediment-water interface. Hence, their distributions may be related to food supply. At Cape Hatt there was an apparent relationship between the biomass of surface deposit feeders and bacteria inhabiting the surface layer of sediment. Bunch et al. (1983) reported total bacterial counts at 7 m depth in the study bays at Cape Hatt during 1981. The ranking of bays (7>9>10>11) was the same for bacterial counts and for biomass of surface deposit feeders.

Differences among bays in the biomass of filter feeders at 7 m were not as marked as those at 3 m depth; Bay 7 (reference), rather than Bay 11, supported the lowest filter feeding biomass. Again, the dominance of infaunal biomass by filter feeders (primarily bivalves) is apparent (compare Fig. 22 with Figs. 5 and 9). Variations in the freshwater layer probably did not affect filter feeders at 7 m, in contrast to the situation at 3 m depth. Reduced salinity was much less common at 7 m depth, and water circulation in Bay 11 was probably reduced less at 7 m than at 3 m because the 7 m transects were relatively far from shore. Sediment characteristics (Table 2) may be important in determining biomass of filter feeders at 7 m depth. Most of the filter-feeding biomass consists of burrowing animals, in particular bivalves. The highest gravel content (67%) and the lowest biomass of filter feeders were found in Bay 7; conversely, the lowest gravel content (8%) and the highest filter-feeding biomass occurred in Bay 9. Predation may also be

a factor: the starfish Leptasterias polaris (a predator of bivalves) was considerably more abundant at 7 m depth in Bay 7 than in any other bay (see Section 3.5.2). Starfish are not included with the carnivores discussed in this section because of their large size and sparse distribution; only two individuals were collected by airlift during the study period.

Another possibility, that food supply influences the among-bay distribution of filter feeders, is not supported by the available data. Filter feeders filter particulate matter (mainly phytoplankton) from the water column, and local current patterns could result in differences in the distribution of food. There was some evidence of this in 1982, when chlorophyll a concentrations (a measure of phytoplankton biomass) in the water column were lowest in Bay 7 and, depending on time of year, highest in Bays 9 and 11 (J. Bunch, unpubl. data). In 1981, however, chlorophyll a concentrations were higher than in 1982, and there was little evidence of among-bay variability (J. Bunch, unpubl. data).

3.4.7.d Temporal Variation and Oil Effects

At both depths, the biomasses of all four feeding guilds showed little variability over the four years of the study (Table 15). The only exception was the biomass of deposit feeders at 3 m depth, which differed among sampling periods only when the 1983 data were included (Table 15). In this case, biomass increased in 1983 (Fig. 22).

The tests of potential oil effects--the period x bay interaction terms--all showed that temporal changes in biomass were either lacking or were consistent among bays (Table 15). Thus, there was no evidence of any oil-related change. Nearly all of the variation in the four infaunal feeding guilds examined was spatial. This spatial variability was evident on both small (transect) and larger (bay) scales, and in all four feeding guilds.

3.5 Epibenthos

For the purposes of the present study, the term 'epibenthos' refers to motile members of the benthic community. We include those animals capable of rapid movement through the lower part of the water column (e.g.,

crustaceans). We also include those that move relatively slowly on the sediment surface, but are capable of covering relatively large distances because of their large size (e.g. urchins, starfish). As previously mentioned, the purpose of this definition is to facilitate the interpretation of any changes in faunal densities in the study bays after oiling. In the cases of the above animals, it is not possible to distinguish with certainty the relative roles of mortality and emigration in determining any changes in densities.

3.5.1 Crustaceans

The available data on highly motile epibenthic crustaceans at Cape Hatt were from the same airlift samples upon which infaunal results were based. Estimates for epibenthic crustaceans likely are not as accurate as those for infauna, however, because of escape of organisms from the area sampled and inclusion of those inadvertently drawn into the airlift from outside the 0.0625 m^2 sampling area. A modification to the sampler, developed for the EAMES program to overcome this shortcoming (see Thomson and Cross 1980), was not practical in the present study because of difficulties in operating the airlift in the mixed sediment-rock substrate. No quantitative estimates are available for the extent to which epibenthic crustaceans were over- or underestimated in the present study. However, there is no reason to expect differences among bays or periods in the accuracy of our estimates, so conclusions about oil effects are not affected.

3.5.1.a Group and Species Composition

Epibenthic crustaceans collected in the study bays at Cape Hatt included ostracods, amphipods, cumaceans, isopods, decapods and nebaliaceans. Ostracods, the numerically dominant taxon, comprised 63.5% of total crustaceans collected during the study. Amphipods and cumaceans made up 29.8% and 6.5% of total numbers, respectively. Isopods, decapods and nebaliaceans were present in very small numbers. Percent contributions of dominant crustaceans to total epibenthic density and biomass at each depth are shown in Table 16. A complete species list is included in Appendix C.

Table 16. Percent contribution of dominant crustaceans to total epibenthic biomass and density at each of two depths in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Based on 526 airlift samples, each covering 0.0625 m^2, from each of 3 and 7 m depths.

Depth	Dominant Taxa by Numbers		% of total epibenthic numbers	Dominant Taxa by Biomass		% of total epibenthic biomass
3 m	Guernea sp.[3]	(A)	13.67	Anonyx spp.	(A)	24.72
	Stenothoidae spp.[3]	(A)	12.85	Sclerocrangon boreas	(D)	19.14
	Lasprops fuscata	(C)	10.38	Weyprechtia pinguis	(A)	8.77
	Ostracoda (Podocopa)		7.76	Parosdiceros lynceus	(A)	6.81
	Monoculodes spp.[3]	(A)	7.33	Pontoporeia femorata	(A)	4.85
	Calliopiidae spp.[3]	(A)	6.17	Monoculodes spp.	(A)	4.25
	Protomedia fasciata	(A)	5.62	Orchomene minuta	(A)	4.18
	Anonyx spp.[3]	(A)	5.24	Onisimus litoralis	(A)	4.16
	Orchomene minuta	(A)	4.97	Boeckosimus plautus	(A)	3.56
	Parosdiceros lynceus	(A)	3.57	Ostracoda (Myodocopa)		2.45
	Total % contribution		77.56	Total % contribution		82.89
	Total epibenthic density (no./m^2)		473.2	Total epibenthic biomass (g/m^2)		2.37
7 m	Ostracoda (Myodocopa)		72.35	Ostracoda (Myodocopa)		33.65
	Guernea sp.[3]	(A)	7.26	Anonyx spp.	(A)	29.32
	Lasprops fuscata	(C)	4.01	Sclerocrangon boreas	(D)	9.94
	Orchomene minuta	(A)	3.55	Orchomene minuta	(A)	5.20
	Pontoporeia femorata	(A)	2.64	Pontoporeia femorata	(A)	5.11
	Anonyx spp.[3]	(A)	2.16	Parosdiceros lynceus	(A)	2.38
	Brachydiastylis resima	(C)	1.24	Argis sp.	(D)	2.14
	Monoculodes spp.[3]	(A)	1.15	Sclerocrangon ferox	(D)	1.05
	Calliopiidae spp.[3]	(A)	0.59	Guernea sp.	(A)	0.99
	Parosdiceros lynceus	(A)	0.56	Lasprops fuscata	(C)	0.94
	Total % contribution		95.51	Total % contribution		90.72
	Total epibenthic density (no./m^2)		2732.8	Total epibenthic biomass (g/m^2)		10.74

(A) = amphipod, (C) = cumacean, (D) = decapod.

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

[3] Stenothoidae includes Metopella and Metopa; Calliopiidae includes Apherusa. Genera indicated include species listed in Appendix C.

Podocopid ostracods, one species of cumacean and eight amphipod taxa accounted for 77.6% of total numbers at **3 m depth.** The three most abundant taxa of epibenthic animals were the amphipod genus Guernea, the amphipod family Stenothoidae, and the cumacean Lamprops fuscata; these three taxa were about equally abundant. Only four species were dominant (i.e. among the top 10 species) in terms of both biomass and density: the amphipods Anonyx spp. (primarily A. nugax and unidentified juveniles), Orchomene minuta, Monoculodes spp. (including five species) and Paroediceros lynceus (Table 16).

At **7 m depth,** the 10 most dominant taxa made up 95.5% of numbers of animals collected, and myodocopid ostracods alone contributed 72.4% of total numbers. Guernea sp. and Lamprops fuscata were also important community members at this depth, ranking second and third in terms of density. Seven taxa (ostracods, L. fuscata and five amphipods) were dominant in terms of both biomass and density (Table 16). Three large and sparsely distributed decapods completed the list of 10 dominant taxa in terms of biomass. All of these species are common in nearshore arctic waters (Steele 1961; Sekerak et al. 1976; Buchanan et al. 1977; Thomson et al. 1978; Thomson and Cross 1980).

3.5.1.b Distribution of Species

3.5.1.b.i Spatial Effects

There was considerable variability among transects in the densities of crustaceans, indicating patchy distributions on a small scale (50 m). This variability was somewhat greater at 3 m than at 7 m depth (Table 17). At 3 m depth, all dominant taxa showed small scale (transect) variation in at least two of the three analysis types. Only the amphipods Calliopiidae spp. and Anonyx spp. were evenly distributed among transects, and this was true only during 1981 and 1982 sampling periods (Table 17). At 7 m depth, densities of 9 of 11 taxa differed among transects according to at least one of the three analysis types. The exceptions were the cumacean Lamprops fuscata and the amphipod Monoculodes spp., which were evenly distributed along the transects in all bays and periods.

Table 17. Summary of three-factor analyses of variance for the densities of dominant epibenthic crustaceans in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. Significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001) are shown for three analysis types[3]; a single value indicates that the results of all three analysis types were consistent.

Depth	Taxon	Source of Variation				
		Period	Bay	Period x Bay[5]	Transect (Bay)[4]	Per x Trans (Bay)[4]
3 m	Total epibenthos	*/ns/ns	*/ns/ns	ns	***	ns/*/**
	Amphipoda	**/*/ns	*/ns/ns	ns	***	ns/*/**
	Gammaracanthus sp.[7]	ns/ns/***	**/**/***	ns	***/***/**	*/*/ns
	Stenothoidae spp.[7]	ns/ns/6	***/***/6	ns/ns/**	***/**/**	ns
	Calliopiidae spp.[7]	6/6/***	6/6/***	**/***/ns	**/ns/**	ns
	Anonyx spp.[7]	6	6	*/***/**	**/ns/*	ns
	Orchomene minuta	ns	**/*/ns	ns	***	ns/ns/**
	Monoculodes spp.[7]	ns	*	ns	***	*/***/**
	Paroediceros lynceus	ns	ns/ns/**	ns	***	*/**/ns
	Cumacea	ns	**/**/***	ns	***	ns
	Lamprops fuscata	ns	**/**/***	ns	***	ns
7 m	Total epibenthos	ns/**/ns	ns	ns	***	*/ns/*
	Amphipoda	***/***/*	***/**/*	ns	ns/*/**	ns/ns/**
	Gammaracanthus sp.[7]	***/***/ns	ns/***/*	ns	*/ns/**	ns/ns/*
	Calliopiidae spp.[7]	6/6/**	6/6/**	***/***/ns	ns/ns/**	ns
	Anonyx spp.[7]	**/ns/ns	ns	ns	*/**/**	**
	Monoculodes spp.[7]	***/***/**	**/ns/ns	ns	ns	ns
	Paroediceros lynceus	*/ns/ns	***	ns	***	ns
	Pontoporeia femorata	ns/**/**	**/***/***	ns	***	ns
	Cumacea	*/*/**	***	ns	ns/ns/*	ns
	Lamprops fuscata	*/*/**	***/***/**	ns	ns	ns
	Ostracoda (Myodocopa)	ns	ns/**/***	ns	***	*/ns/ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

[3] Results are shown for analyses involving (1) Bays 9, 10, 11 in 1980-1982, (2) Bays 7, 9, 10, 11 in 1981 and 1982, and (3) Bays 7, 9, 11 in 1981-1983; detailed ANOVA results are given in Appendices R to T.

[4] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.

[5] The Period x Bay term is the test of oil effects.

[6] Interpretation of main effects confounded by significant interaction of Period x Bay term.

[7] Stenothoidae includes Metopella and Metopa; Calliopiidae includes Apherusa. Genera indicated include species listed in Appendix C.

There was little indication that densities of total epibenthos varied among bays, but for most specific taxa that were examined spatial variation on this scale was considerable at both depths. At 3 m depth, bay differences were significant in 20 of 27 tests where main effects were not confounded by significant interactions (Table 17). Guernea sp. and Lamprops fuscata, each contributing over 10% of total epibenthic numbers at 3 m depth during the study, were most abundant in Bay 9 (dispersed oil release bay). In contrast, Bay 9 supported the lowest densities of amphipod families Stenothoidae, Calliopiidae and Oedicerotidae (Monoculodes spp. and Paroediceros lynceus). Densities of Orchomene minuta were highest in Bay 10 (dispersed oil contamination) and similar in the other three bays (Fig. 23).

At 7 m depth, 21 of 31 tests for among-bay variability were significant (Table 17). Bay 11 (surface oil release) supported the highest density of total amphipods and cumaceans (Fig. 24). The unusually high mean amphipod density (2497.6 individuals/m^2) in Bay 10 during August 1982 was the result of one sample containing 2500 individuals of Orchomene minuta (Appendix Q). Densities of myodocopid ostracods (72.4% of total crustacean numbers) and Pontoporeia femorata were highest in Bay 7 (reference), whereas Guernea sp. was least abundant in this bay. Paroediceros lynceus was most abundant in Bays 10 and 11, and was very rare in the other two bays.

3.5.1.b.ii Temporal Effects

Temporal variation was considerably less common at 3 m than at 7 m depth. At 3 and 7 m depths, respectively, period effects were significant in 5 of 29 and 20 of 31 tests where main effects were interpretable (Table 17). Furthermore, at 3 m depth results of the three analysis types were not consistent for any of the taxa where temporal variability was indicated. Density changes in total epibenthos, total amphipods and Guernea sp. were variable, particularly in Bay 9, but the overall trend was toward increased densities through time. Calliopiidae spp. showed distinct seasonal variation (August to September increases; Fig. 23).

At 7 m depth the most common type of temporal variability was an increase in density over the study period. Densities of the amphipods Monoculodes spp. and Pontoporeia femorata, however, decreased between

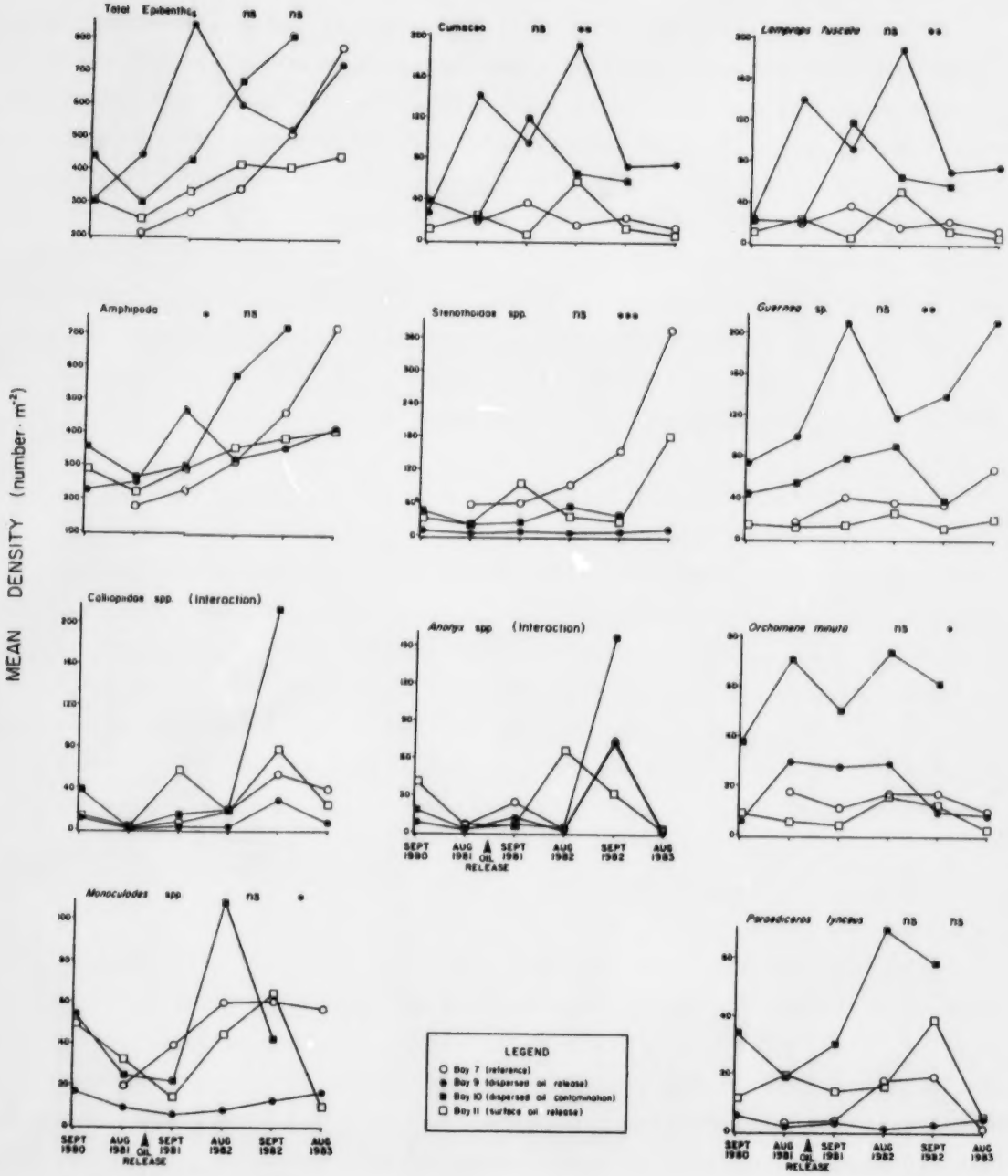


Figure 23. Mean density (no./m^2) of total epibenthos and dominant epibenthic groups and species at 3 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples for each bay and period, and significance levels are shown for period effects, followed by bay effects. Note that the ordinate does not always begin at zero.

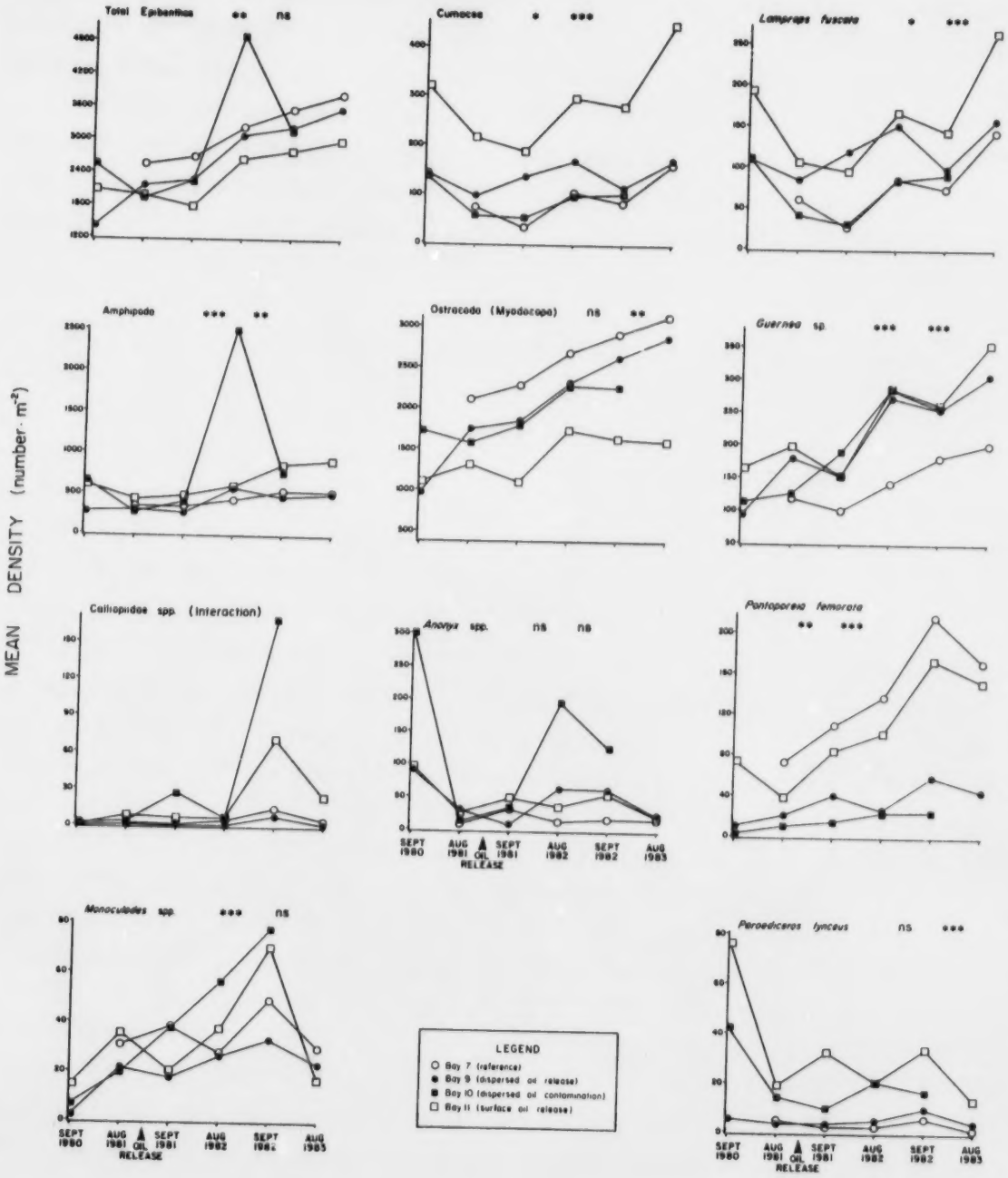


Figure 24. Mean density (no./m^2) of total epibenthos and dominant epibenthic groups and species at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples for each bay and period, and significance levels are shown for period effects, followed by bay effects. Note that the ordinate does not always begin at zero.

September 1982 and August 1983; similar trends (i.e. non-significant decreases) were also observed in some other species (Fig. 24). In contrast, densities of Paroediceros lynceus and Anonyx spp. decreased markedly from September 1980 to August 1981, and generally remained low until 1983. Cumaceans (including the dominant species Lamprops fuscata) and the amphipod Guernea sp. varied seasonally (August to September decreases). Calliopiidae spp. showed the same trend as at 3 m depth--seasonal (August to September) increases.

Causes of the observed temporal variation in epibenthic crustaceans at Cape Hatt are not known. Elsewhere, low winter temperatures may be responsible for low abundance and productivity of crustaceans (e.g., the cumacean Diastylis rathkei; Rachor et al. 1982), but there is little year-to-year variation in winter water temperatures in the Arctic. Seasonal and year-to-year variation in freshwater runoff was apparent at Cape Hatt, but at 3 m depth salinity fluctuations were greater, and temporal variation in epibenthos was less common than at 7 m depth. Hence the observed annual or seasonal variability in epibenthic densities probably was not related to salinity. Some epibenthic species may be food-limited, as suggested by Elmgren (1978) for Pontoporeia affinis and P. femorata populations in the Baltic Sea. Chlorophyll a concentrations in the study bays at Cape Hatt were higher in 1981 than in 1982 (J. Bunch, unpubl. data), and this may have been related to the observed population increases in 1982 and subsequent decreases in 1983 in P. femorata and Monoculodes spp. Not all species showed the same type of temporal change at Cape Hatt, however, so it is clear that food supply was not the only factor affecting temporal variability in epibenthos.

3.5.1.b.iii Oil Effects

Oil and dispersed oil released at Cape Hatt in 1981 did not cause any marked reductions in densities of subtidal epibenthic crustaceans (Figs. 23 and 24). In contrast, populations of the dominant intertidal amphipod Gammarus setosus were reduced in both the surface and dispersed oil release bays during the first post-spill sampling period (Cross and Martin 1983). Densities had increased by the following summer, but effects on the population structure of G. setosus were still apparent in Bay 11 during spring and summer of 1982 (see Section 3.5.1.c).

In subtidal epibenthic crustaceans, some of the largest density decreases occurred between the two pre-spill sampling periods, and the overall trend was toward density increases over the study period. However, tests of period x bay interactions showed possible effects of oil on three amphipod taxa at 3 m depth (the families Stenothoidae and Calliopiidae and the genus Anonyx), and on Calliopiidae spp. at 7 m depth. In these cases interactions between period and bay effects were significant in at least one of three types of analysis of variance (Table 17).

A possible oil effect was indicated for densities of the family **Stenothoidae at 3 m depth**, but only according to the analysis that excluded data from Bay 10 and included data from August 1983 (Table 17). Inspection of the data (Fig. 23) shows that the interaction was apparently not related to the oil releases. Densities were very low in the dispersed oil release bay throughout the study period, whereas densities increased markedly in the reference and the surface oil release bays between September 1982 and August 1983 (Fig. 23). These density increases apparently were unrelated to oil levels in sediments because the increases occurred in the bays that had the lowest and highest concentrations of oil in sediments (Fig. 4).

A second possible oil effect was indicated for **Calliopiidae spp. at 3 and 7 m depths.** At each depth, the bay x period interaction term was significant in the two analysis types that included data from Bay 10 (dispersed oil contamination) and excluded data from August 1983 (Table 17). The spatial pattern of density changes with time was very similar at 3 and 7 m depths (Figs. 23 and 24). The main source of the observed bay x period interaction was probably (1) the disproportionate increase in calliopiid densities at both depths in Bays 9 and 10 between August and September 1982, and (2) the earlier (August to September 1981) increases in Bay 11 (3 m) or Bay 10 (7 m) relative to little change in the other bays (Figs. 23 and 24). The pattern of increase among bays suggests a delayed effect of the dispersed oil release at both depths, and an immediate effect of the surface oil release at 3 m depth. However, our observations following the oil releases (see Section 3.4.3.c), together with the observed temporal changes in oil levels in sediments (Fig. 4), suggests the converse, that immediate effects would be expected from the dispersed oil release, and delayed effects from

the surface oil release. Therefore, the observed bay x period interactions in Calliopiidae spp. at 3 and 7 m depths were not attributable to effects of the dispersed or surface oil releases.

The family Calliopiidae at Cape Hatt was represented almost entirely by the genus Apherusa; Apherusa megalops was the dominant species, and A. borealis and A. glacialis were also present. Most Apherusa spp. in the samples were small juveniles released in the previous spring. These juveniles migrated into the study bays during August and September, probably from deeper water. Thus the high densities in 1982 indicate (1) that juveniles were not adversely affected by the oil concentrations present in sediments in 1982, and (2) that reproduction in the summer or fall of 1981 was not adversely affected by oil concentrations in the water or sediments during 1981. There is some evidence that benthic species of Apherusa may be associated with macrophytic algae. Large numbers of calliopiid amphipods (including A. megalops and A. glacialis) were collected in association with Agarum cribrosum at 10 m depth at Cape Hatt (C. Martin, unpubl. data), and A. borealis is associated with littoral algae in European waters (Chevreux and Fage 1925). A similar habitat association for Apherusa spp. at Cape Hatt may have reduced exposure to oiled sediments in the study bays. Otherwise, their weak exoskeletons would likely make them vulnerable to direct oiling.

Rather than an effect of oil on Calliopiidae spp., the observed interaction effect may have been a result of seasonal migration to 3 and 7 m depths and general reproductive success in 1981 (hence the overall density increase in 1982), together with habitat suitability in a particular bay or bays. Primary productivity was relatively high in 1981 (see above), and a concomitant increase in deposited organic matter may have contributed to reproductive success. Densities of Calliopiidae spp. increased between August and September in each year and in each bay at 3 m, and in five of eight cases at 7 m depth (Figs. 23 and 24; Appendix Q). The disproportionate density increase in Bay 10 during 1982, at least at 3 m depth, may have been related to a similar disproportionate increase between 1981 and 1982 in the biomass of macroalgae in Bay 10 (see Section 3.6). Increases of other epibenthic taxa were also noted in Bay 10 in 1982, particularly at 3 m depth. These taxa included the free-burrowing oedicerotids Monoculodes spp.

and Paroediceros lynceus, and the free-swimming lysianassids Anonyx spp. (Figs. 23 and 24).

Period x bay interaction terms for the amphipod genus Anonyx at 3 m depth were significant in all three analysis types (Table 17). No marked changes in density were evident immediately after the oil releases in August 1981. In the following year densities increased in all study bays, but to varying degrees and at different times (Fig. 23). In the surface oil release bay, high densities of Anonyx spp. occurred in August 1982, whereas in the other bays densities did not increase until September. It is possible that the earlier density increase in Bay 11 was related to concentrations of oil in sediments at 3 m depth during 1982 (highest in Bay 11). Densities of Anonyx spp. did not increase in August 1983 when oil concentrations were higher still, but the oil in 1983 was presumably weathered to a much greater extent than in 1982. This possible oil effect is considered further in the following section.

3.5.1.c Length-Frequency Distributions

Sublethal effects of environmental stress may be induced in one stage of development but may not become apparent until a later stage of development (Rosenthal and Alderdice 1976). Sublethal effects of oil or other pollutants, induced in this way, can eventually be detected at the population level only if successive generations are available for monitoring. This is not the case for benthic organisms with pelagic developmental stages, where successive generations are recruited to populations in different, and sometimes distant, locations. Many crustaceans, however, do not have pelagic larval stages, but brood eggs and larvae, and release the young as fully developed individuals. Thus juveniles of non-pelagic amphipods are recruited from local populations, and any effects of stress on reproductive processes may be detectable at the site of the disturbance. Also, recolonization of large disturbed areas will be slow in invertebrates with direct development (Chia 1970).

In the present section we present length-frequency data for two amphipod species, Anonyx nugax and Pontoporeia femorata, in order to assess the effects of oil and dispersed oil on reproduction, and hence recruitment, in

these species at Cape Hatt. Cross and Martin (1983) reported effects of the surface oil release at Cape Hatt on the population structure of Gammarus setosus in under-ice and intertidal habitats. The release of Gammarus juveniles on the under-ice surface in Bay 11 was delayed in spring 1982, and the 0+ year class was reduced in size in the intertidal habitat during the following August and September. In the subtidal habitat at Cape Hatt, Anonyx spp. (primarily A. nugax and unidentified juveniles) were among the dominant taxa at both 3 and 7 m depths in terms of both density and biomass; Pontoporeia femorata was important in terms of biomass at both depths, but was among the top ten contributors to numbers only at 7 m depth (Table 16). Effects of oil on both of these species have been studied previously (Foy 1978, 1979, 1982; Elmgren et al. 1980; Elmgren et al. 1983).

Length-frequency distributions of Anonyx nugax and Anonyx juveniles are given in Figure 25. The Anonyx juveniles were likely A. nugax, because all other Anonyx species were rare at Cape Hatt. Several aspects of the life history of A. nugax are apparent in these data. The abundance of all size classes, and particularly small individuals, varied annually--high in 1980 and 1982, and low in 1981 and 1983. Polymodality was evident, with modal size classes at 4-6 mm, 8-9 mm, 12-15 mm and >20 mm. Larger individuals were rare at Cape Hatt, but in the central Arctic three larger size classes have been found, with modes at 24-25 mm, 32-35 mm and 40-42 mm (Foy 1978). Thus it is possible that four of six age classes were present in shallow water at Cape Hatt. However, Foy (1978) suggested that the breeding period of A. nugax in the central Canadian arctic archipelago is extremely long, lasting at least from December to August. He was unable to determine whether the observed polymodal size-frequency distributions represented seasonal periods of peak brood production or true year classes.

At Cape Hatt, growth was evident in the smallest size class between August and September (from about 5 to 6 mm). This size class showed a clear preference for the 3 m depth (shaded portion of Fig. 25). In Bays 9 and 10 these small Anonyx apparently moved from 7 to 3 m depth between August and September. Larger A. nugax, on the other hand, clearly preferred the 7 m over the 3 m depth in both months. Numbers of large individuals increased in September, probably indicating immigration from deeper water. Life stage

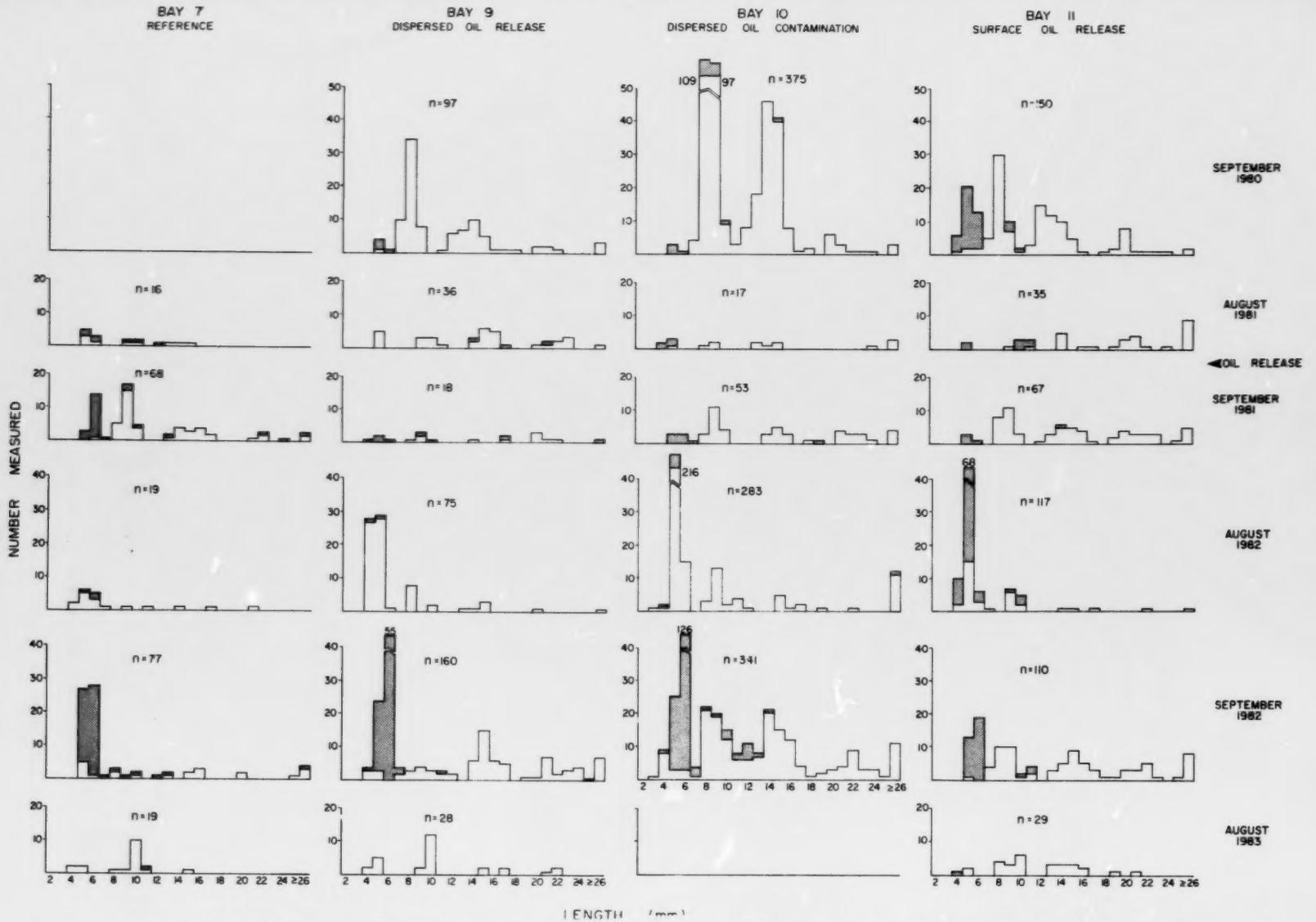


Figure 25. Length-frequency distributions of Anonyx nugax (>10 mm long) and Anonyx juveniles (≤10 mm) at 3 m depth (dark portion of each histogram) and at 7 m depth (light portion) in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Sample sizes are given for all undamaged individuals in 24 samples from each bay and period.

segregation by spatial separation has also been observed in two sand-burrowing amphipod species (Haustoriidae) (Croker and Hatfield 1980), and two intertidal species (Gammaridae) (Skadsheim 1983).

The bay x period interaction effect in densities of Anonyx spp. at 3 m depth (see previous section) indicated a possible effect of oil in Bay 11 sediments. This possible oil effect was also evident from length-frequency data for Anonyx nugax in 1982. Juveniles 4-5 mm long were common in Bay 11 at 3 m depth during August, but did not become common at 3 m in the other bays until September. The density increases were probably the result of migration from 7 to 3 m depth (Fig. 25). This may indicate a behavioural response to oil in sediments; oil concentrations were higher in Bay 11 than in Bays 7, 9 and 10. Sublethal effects of oil on behavioural patterns have been documented in a closely related organism, Boeckosimus affinis (Percy 1976, 1977; Percy and Mullin 1977; Busdosh et al. 1978; Busdosh 1981). These effects, although less severe when the oil was weathered, included disruption of feeding, suppression of burrowing activity, and decreases in distance and duration of movement. At high oil levels and after prolonged exposure to low concentrations they also lost the ability to avoid oil-contaminated food and sediment. Because of the low numbers of Anonyx juveniles collected at Cape Hatt in August 1981, however, it is not known whether or not the earlier migration to shallow water in Bay 11 during August 1982 was a natural phenomenon.

There was no strong evidence of an oil effect on reproduction or size-specific mortality in Anonyx spp. (Fig. 25). Numbers of A. nugax and particularly Anonyx juveniles were reduced in 1981, but this was true in the pre-spill as well as the post-spill sampling period. In the pre-spill period, Anonyx juveniles in the dispersed oil bays and, to a lesser extent, in the surface oil release bay, were mainly represented by 8-9 mm juveniles. In 1982, this size class was less frequent than 5-6 mm juveniles. However, the same change occurred between September 1981 and September 1982 in the reference bay, so we cannot conclude that dispersed oil affected reproduction of Anonyx nugax.

Length-frequency distributions for Pontoporeia femorata at three depths in the reference and surface oil release bays are given in Figure 26. Sampling at the additional depth (5 m) was carried out only in 1981 and 1982, and 5 m was the only depth sampled in May 1981 and 1982. Length-frequency distributions in the dispersed oil bays are not presented because too few P. femorata were collected (Figs. 23 and 24; Appendix Q).

Polymodality in the length-frequency distributions is evident in both bays, with modal size classes at 2 or 3 mm, 5-6 mm, 8-10 mm and about 14 mm. Steele and Steele (1978) reported that arctic and boreal Pontoporeia femorata bred in winter and released their young in spring or summer. A size of 5-6 mm was reached by autumn, but maturity was not reached until the second year (at a length of 10 mm). Pontoporeia femorata may produce a second brood at 3 years of age (16 mm). The occurrence of four modal size classes at Cape Hatt indicates that (1) growth is slower, and P. femorata lives for four years, or (2) 3-4 and 5-6 mm cohorts were released at two different times of the same year, viz. summer and spring, respectively. The lack of polymodality in the 8-10 mm cohort tends to corroborate the four year life cycle, although relatively few 8-10 mm animals were collected. It is also evident that the same type of size class separation by depth observed in Anonyx juveniles and Anonyx nugax occurred in P. femorata. In P. femorata, however, the larger size classes (2 and 3, or 3 and 4 year-olds) also occurred in shallow water, particularly in Bay 11.

There was no indication that densities of Pontoporeia femorata were affected by oil (Table 17). Length-frequency data, however, suggest that population structure may have been affected in the surface oil release bay. At both depths, newly-released juveniles (3 mm long) were rare in August 1983, whereas recruitment of this size class was relatively strong in Bay 11 in the two previous years, and in all three years in Bay 7. It is possible that high oil levels in Bay 11 sediments during 1982 (7.4-8.8 µg/g in August 1982) disrupted some aspect of reproduction in P. femorata adults in the winter of 1982. Elmgren et al. (1983) reported an increase in the frequency of abnormally developed eggs in P. femorata females during the winter following the Tsesis oil spill. It is also possible that oil concentrations in Bay 11 during 1983 (16.0 and 46.1 µg/g at 7 and 3 m depths, respectively)

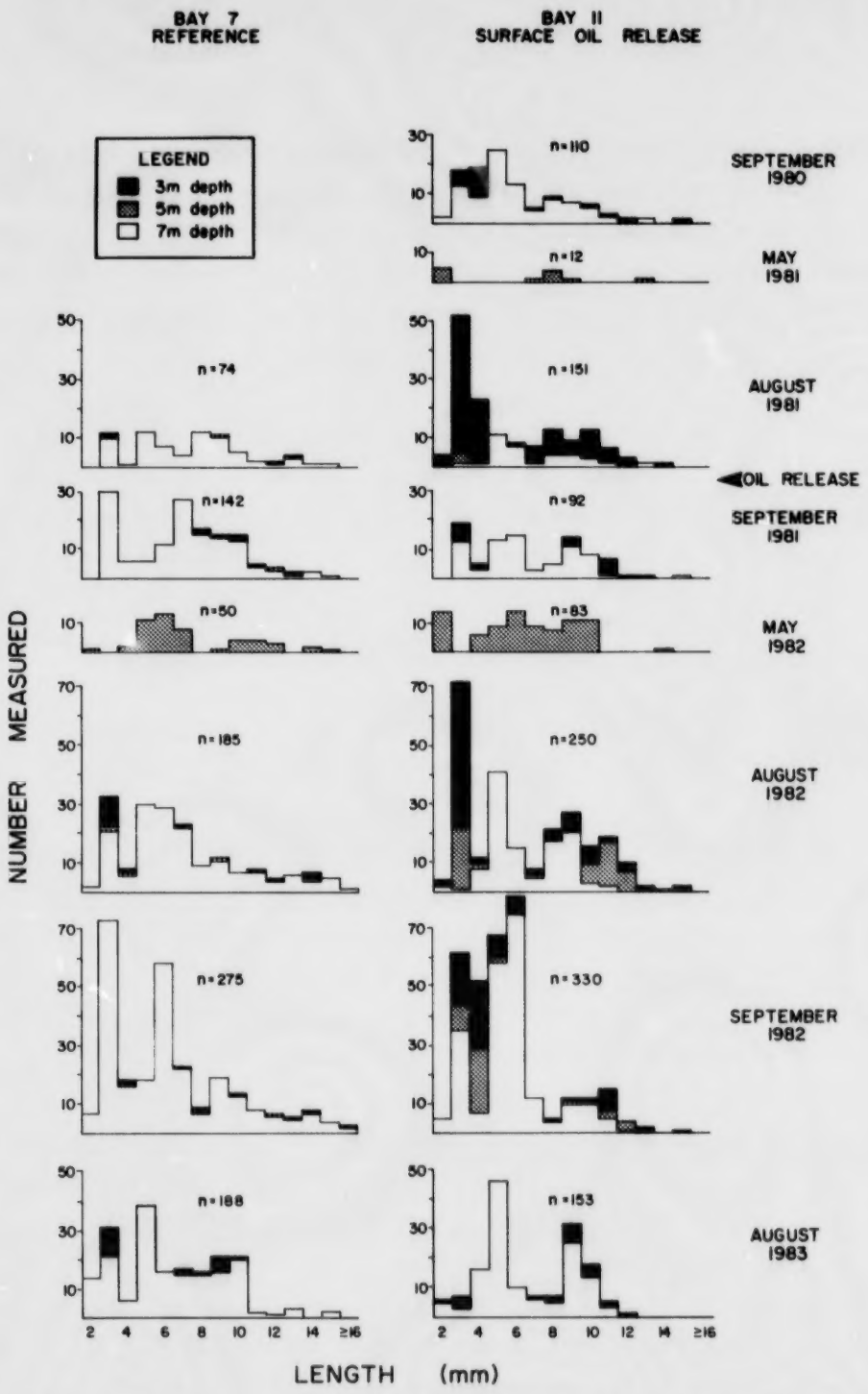


Figure 26. Length-frequency distributions of Pontoporeia femorata at 3, 5 and 7 m depths in two bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Sample sizes are given for all undamaged individuals in 24 (3 and 7 m depths) or 10-16 (5 m depth) samples from each bay and period. Sampling in May was carried out only at 5 m depth and only in 1981 and 1982 (see text).

directly caused the mortality and/or emigration of the newly-released juveniles. This is less likely, however, because the oil was presumably weathered to a much greater extent in 1983 than in 1982.

In summary, oil and dispersed oil did not cause any marked reductions in densities of subtidal epibenthic crustaceans during the two years following the experimental oil releases. We tested for subtle changes in densities of 11 epibenthic taxa at each of 3 and 7 m depths, and found changes that might be related to oil in only one taxon at 3 m depth. These changes and one other possible oil effect were apparent in length-frequency data. In 1982, juvenilies of the amphipod genus Anonyx apparently migrated from 7 to 3 m depth earlier in the surface oil release bay than in the other bays. This may have been a behavioural response to the high levels of oil in the sediments of this bay. There was no indication that densities of the amphipod Pontoporeia femorata were affected by oil, but length-frequency data suggested that population structure was affected in the surface oil release bay. The scarcity of newly-released juveniles in this bay during August 1983 indicated that reproduction in the previous winter may have been adversely affected by oil in sediments. Thus there were indications that the surface oil release had a delayed effect (1 or 2 years) on two subtidal amphipod species. No effect of dispersed oil on subtidal epibenthic crustaceans was detected.

Cross and Martin (1983) reported effects of the oil releases at Cape Hatt on the density, biomass and population structure of Gammarus setosus in under-ice and intertidal habitats. Direct oiling of intertidal populations in Bay 11 caused immediate mortality, particularly in the 0+ year class. This cohort was almost absent from the under-ice surface in the following spring but was well represented in the intertidal habitat one year following the oil release. These individuals must have been recruited from adjacent areas. The release of Gammarus juveniles on the under-ice surface in Bay 11 was delayed in spring 1982, and the 0+ year class was reduced in size in the intertidal habitat during the following August and September. The dispersed oil release, on the other hand, seems to have affected older Gammarus setosus (1 and 2+ year classes). Densities of these individuals were markedly reduced approximately one week following the release, but it is uncertain

whether mortality or emigration was the cause of this decrease. Densities on the under-ice surface were low in both the pre- and the post-spill years. No effects of the dispersed oil release were apparent in abundance and population structure data collected in the intertidal habitat one year following the release.

3.5.2 Echinoderms

The urchin Strongylocentrotus droebachiensis is widely distributed and often relatively abundant (up to 14 individuals/m^2) in the Lancaster Sound area, whereas the distribution of the starfish Leptasterias polaris is more restricted (Thomson and Cross 1980). Both species are of interest because of their trophic positions. Strongylocentrotus droebachiensis is an herbivore whose impact on benthic algal populations has been found to be considerable on both the east and west coasts of Canada (Miller and Mann 1973; Foreman 1977). Leptasterias polaris is a top predator feeding primarily on large bivalves, and hence may be affected indirectly by oil through changes in bivalve populations. Thus, in spite of the interpretational difficulties caused by the mobility of these animals, densities of urchins and starfish were monitored carefully throughout this study. Too few urchins or starfish were present at 3 m depth in the study bays to warrant discussion.

Densities of Strongylocentrotus droebachiensis and Leptasterias polaris at 7 m depth in the study bays during each systematic sampling period, and immediately (2 to 4 days) after the dispersed oil release, are shown in Table 18 and Figure 27. Results of analyses of variance for 3 bay/7 period and 4 bay/6 period analyses are given in Table 19. In these analyses, the 2-4 day post-spill data are treated as an additional period. Unfortunately, there are no data from Bay 11 in the period immediately after the surface oil release; this results in an empty cell in both of these analyses.

Differences among transects were not significant for either species in either type of analysis, nor was any period x transect interaction term significant. Among-bay differences, on the other hand, were significant for Leptasterias polaris in both analyses. Leptasterias polaris was most abundant in Bay 7, and occurred at a relatively low and similar abundance in Bays 9, 10 and 11 (Table 18; Fig. 27). Temporal differences were also

Table 18. Densities of urchins (Strongylocentrotus droebachiensis) and starfish (Leptasterias polaris) at 7 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Data are based on 15 in situ counts, each covering 10 m^2, in each period-bay combination.

Species	Period	Bay 7		Bay 9		Bay 10		Bay 11	
		Date[3]	Mean ± SD	Date[3]	Mean ± SD	Date[3]	Mean ± SD	Date[3]	Mean ± SD
Urchin ($no./m^2$)	Pre-spill 1		-	30/8	4.4 ± 1.5	13/9	1.6 ± 0.7	12/9	1.0 ± 0.4
	Pre-spill 2	15/8	10.0 ± 3.4	6/8	7.6 ± 2.2	13/8	1.9 ± 0.9	10/8	1.3 ± 0.5
	*	31/8	8.6 ± 2.2	29/8	2.9 ± 1.1	29/8	3.0 ± 1.1		-
	Post-spill 1	2/9	7.8 ± 3.5	3/9	5.5 ± 2.8	6/9	2.3 ± 0.7	1/9	1.3 ± 0.7
	Post-spill 2	12/9	5.8 ± 2.3	10/8	5.0 ± 1.8	9/8	1.6 ± 0.7	8,14/8	1.2 ± 0.5
	Post-spill 3	5/9	5.8 ± 2.6	5/9	5.4 ± 1.6	3/9	2.3 ± 0.8	2/9	1.2 ± 0.6
	Post-spill 4	9/8	6.3 ± 1.8	6/8	3.8 ± 1.0	11/8	1.1 ± 0.5	6/8	0.7 ± 0.4
Starfish ($no./10\ m^2$)	Pre-spill 1		-	30/8	1.0 ± 1.1	13/9	1.9 ± 1.3	12/9	0.7 ± 1.1
	Pre-spill 2	15/8	3.3 ± 2.5	6/8	1.1 ± 0.9	13/8	1.3 ± 0.9	10/8	0.5 ± 0.8
	*	31/8	5.8 ± 3.6	29/8	1.1 ± 1.5	29/8	2.3 ± 1.5		-
	Post-spill 1	2/9	4.5 ± 3.3	3/9	1.9 ± 1.2	6/9	2.7 ± 1.8	1/9	1.6 ± 2.0
	Post-spill 2	12/8	2.6 ± 2.0	10/8	1.5 ± 1.6	9/8	1.8 ± 1.2	8,14/8	1.1 ± 1.0
	Post-spill 3	5/9	3.3 ± 3.4	5/9	1.3 ± 1.3	3/9	1.9 ± 1.4	2/9	0.7 ± 0.7
	Post-spill 4	9/8	1.2 ± 0.9	6/8	0.3 ± 0.5	11/8	1.0 ± 0.8	6/8	0.4 ± 0.8

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981), * (2 days after dispersed oil release) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).
[3] Dates shown are day and month for each year.

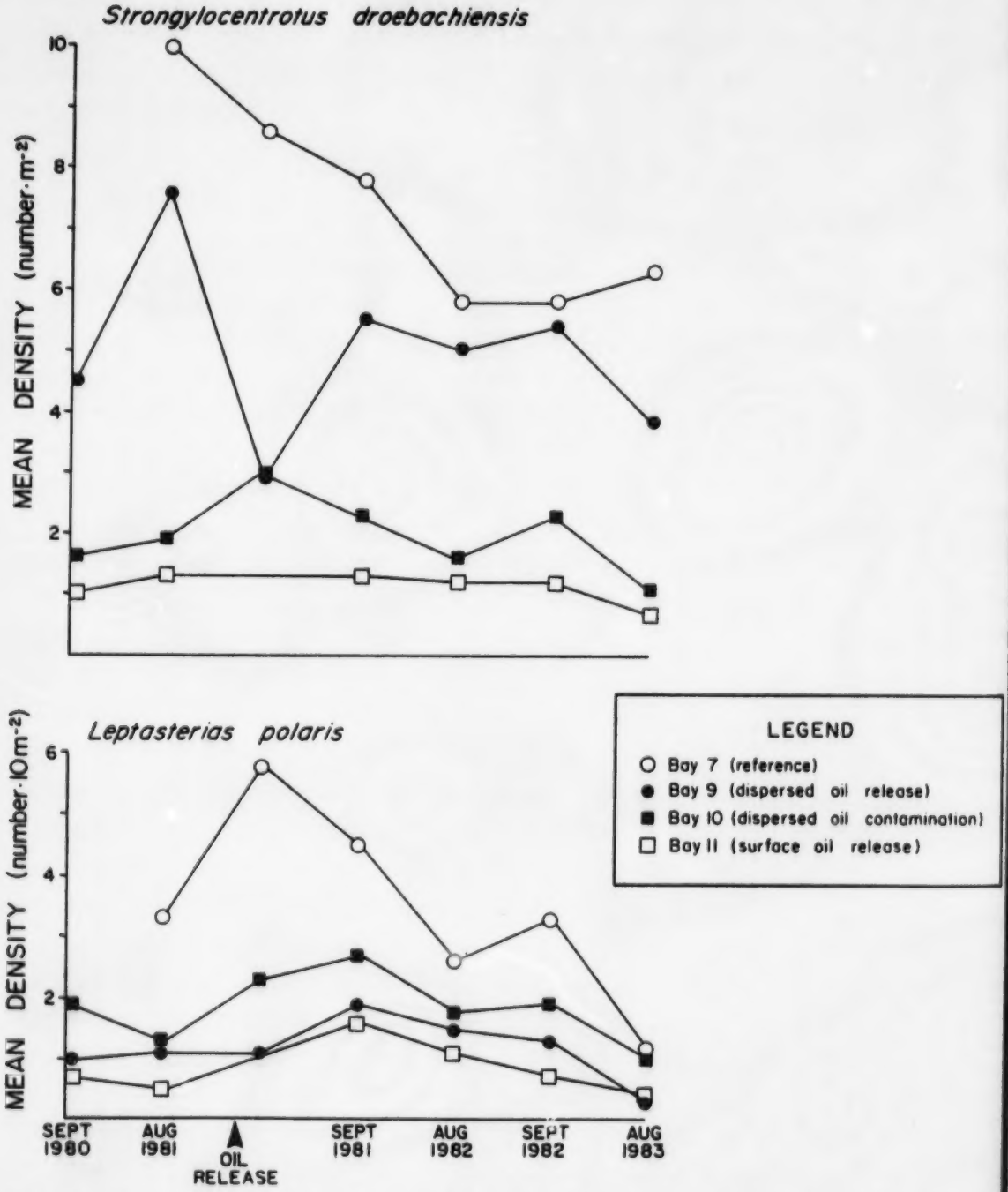


Figure 27. Densities of urchins (Strongylocentrotus droebachiensis--no./m^2) and starfish (Leptasterias polaris--no./10 m^2) at 7 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are based on 15 in situ counts, each covering 10 m^2, from each bay and period. Additional counts were made in Bays 7, 9 and 10 two days following the dispersed oil release.

Table 19. Three-factor analyses of variance for densities[1] of urchins and starfish at 7 m depth in four bays[2] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[3]. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

Species	Analysis[4]	Source of Variation and df[5]				
		Period 6,40(5,46)	Bay 2,40(3,46)	Period x Bay[6] 11,40(14,46)	Transect (Bay) 6,240(8,276)	Per x Trans (Bay) 34,240(38,276)
Strongylocentrotus droebachiensis	3 bay/7 period	–[7]	–[7]	5.37 ***	1.07 ns	0.96 ns
	4 bay/6 period	–[7]	–[7]	6.09 ***	1.25 ns	0.86 ns
Leptasterias polaris	3 bay/7 period	9.57 ***	28.98 ***	0.65 ns	1.07 ns	0.66 ns
	4 bay/6 period	12.88 ***	34.80 ***	1.33 ns	0.64 ns	0.97 ns

1 Based on log-transformed in situ counts within five 1 x 10 m areas on each of three transects in each bay and period.
2 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
3 Pre-spill Periods 1 and 2 (September 1980, August 1981), two days after the dispersed oil release, and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).
4 3 bay/7 period analysis excludes Bay 7; 4 bay/6 period analysis excludes Pre-spill Period 1.
5 Degrees of freedom are shown for 3 bay/7 period analysis, followed by 4 bay/6 period analysis (in parentheses). Period x Transect (Bay) interaction was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects.
6 The Period x Bay term is the test of oil effects.
7 Interpretation of main effects confounded by significant interaction of Period x Bay term.

significant for L. polaris: densities in all four bays were higher in 1981 post-spill sampling periods than in pre-spill periods or in 1982 post-spill periods. Densities decreased in all bays between 1982 and 1983. Bay and period effects for Strongylocentrotus droebachiensis are not given in Table 19 because of the significant period x bay interaction, but inspection of the data shows that urchins were more common in Bays 7 and 9 than in Bays 10 or 11.

The significant bay x period interaction effect for Strongylocentrotus droebachiensis (Table 19), and inspection of the data (Table 18; Fig. 27), indicate that dispersed oil and possibly surface oil did affect urchins. Sources of the significant interaction term likely were (1) the density increase in Bay 9 between the two pre-spill periods relative to no change in Bays 10 and 11 (clearly not an oil effect), (2) the marked decrease and subsequent increase in Bay 9 following the dispersed oil release, and (3) decreases in the three oiled bays, but not the reference bay, between the last two sampling periods. Each of these density changes was significant (one-factor analyses of variance, $P<0.007$).

The changes in abundance of urchins in Bays 9 and 10 immediately following the dispersed oil release were apparently directly related to the high concentrations of dispersed oil in Bay 9 and, to a lesser extent, in Bay 10. The density decrease in Bay 9 likely reflects emigration rather than mortality. Urchins were among the invertebrates that were noticeably affected by the dispersed oil release (see Section 3.4.3.c), but mortality was not one of the observed responses. Engelhardt et al. (1983) reported that Strongylocentrotus droebachiensis exposed to dispersed oil concentrations as low as 0.5 ppm showed behavioural responses including disruption of tube feet responses and spine rigidity, but mortality occurred only (1) after 18 h exposure to 500 ppm dispersed oil, and (2) in only one of three tests designed to simulate conditions in Bay 9 during the dispersed oil release. It is not likely that immobilized urchins were carried away by water currents, because currents in the study bays were never strong. Urchins may have emigrated actively from Bay 9 to deeper, uncontaminated water. Engelhardt et al. (1983) also observed rapid linear movement in

urchins within minutes of being exposed to dispersed oil concentrations of 50 to 250 ppm. However, immediately after the rapid movement phase the urchins became completely immobilized.

In Bay 10, urchin density increased significantly ($F = 10.74$; $df = 1,28$; $P<0.003$) immediately following the dispersed oil release. This increase is less easy to interpret. Dispersed oil entered Bay 10 at a depth of approximately 8-10 m and this may have caused a movement from deep to shallow water. In both bays, densities had returned to pre-spill levels within two weeks of the dispersed oil release.

Decreases in abundance of Strongylocentrotus droebachiensis in the oiled bays between 1982 and 1983 may have been a result of the concurrent large increases in oil concentrations in these bays (there are no 1983 hydrocarbon data for Bay 10). Oil concentrations also increased in the reference bay between 1982 and 1983 but concentrations were considerably lower than in Bays 9 or 11 (Fig. 4; concentrations in replicate samples from Bay 7 were 1.6, 1.8, 2.6, 3.6 and 12.8 ppm--Boehm et al. 1984). Urchins at Cape Hatt are surface deposit feeders, and in September 1981 oil concentrations in their body tissues (including gut contents) were as high as 1050 ppm (Boehm 1983). Thus the high levels of oil in the sediments on which they feed may have caused avoidance of the oiled bays, probably through migration to deeper, uncontaminated areas. Densities in August 1983, however, were only slightly lower than pre-spill values.

These data for Strongylocentrotus droebachiensis, combined with direct observations of effects on urchins and starfish made during and after the dispersed oil release (Section 3.4.3.c.i), indicate that dispersed oil did have an immediate effect, but that recovery occurred quickly. Urchin densities appeared to have returned to pre-spill levels within two weeks of the dispersed oil release. However, increased concentrations of oil in the sediments during 1983 may have reduced urchin densities slightly, probably by causing emigration to deeper water where sediments were cleaner.

3.6 Macrophytic Algae

The benthic marine algae of the North American Arctic have been studied intermittently since the early nineteenth century, but early reports consisted of little more than species lists (Kent 1972). Recently, floristic and ecological studies have been performed in Labrador and Ungava Bay (Wilce 1959), West Greenland (Wilce 1964), Prince Patrick Island (Lee 1966), Pangnirtung Fiord (Kent 1972), and in several areas in the northern and southwestern Canadian Arctic (Lee 1980). These studies have shown that macrophytic algae are a common feature of arctic and subarctic nearshore waters, both on exposed rocky coasts and on soft bottoms. In the latter case, the algae are either loose-lying and still viable or are attached to mud, small rocks, shells and polychaete tubes (R.W. Lee 1966; R.K.S. Lee 1973, 1980). These floristic studies have provided much valuable information on species composition, zonation and reproduction of littoral and sublittoral macrophytes in high latitudes. Quantitative studies of kelps and conspicuous understory algae have also been carried out at several locations in the Lancaster Sound area (Thomson and Cross 1980), but to date combined floristic/biomass studies of benthic macroalgae have not been reported for the Canadian Arctic.

The overall effects of oil on macroalgal communities have not been studied in the Arctic, but Hsiao et al. (1978) determined that *in situ* primary production in two macroalgal species in the Beaufort Sea was significantly inhibited by all types and concentrations (3 to 147 ppm) of oil tested. In other latitudes, studies of the effects of oil spills with and without the use of chemical dispersants have often demonstrated changes in the abundance of littoral and sublittoral macrophytic algae (see National Academy of Sciences 1975, Table 4-1). In some cases widespread mortality has been observed (e.g., Bellamy et al. 1967; Thomas 1973), whereas in other cases no mortality was apparent immediately following the spill (e.g., Nelson-Smith 1968). Subsequent changes following spills have included a proliferation of macroalgal growth, which has been attributed to the oil-related absence of herbivores including sea urchins (North et al. 1965) and limpets (Nelson-Smith 1968).

3.6.1 Community Description

A total of 60 species of benthic algae were collected in the study bays at Cape Hatt (Table 20). This is a relatively small number when compared with the 126 species known in the arctic sublittoral (Wilce 1973) or the 183 arctic species and varieties (littoral and sublittoral) recorded by Lee (1980). This difference undoubtedly is largely attributable to the small area and relatively homogeneous substrate type studied at Cape Hatt relative to the wide geographical coverage and diversity of substrate types included in the above investigations.

The dominant species at 3 m depth in the study bays were Stictyosiphon tortilis, Pilayella littoralis and Dictyosiphon foeniculaceus. Together with tubular diatoms (it was impractical to separate these from P. littoralis), these species comprised 76.1% of total macroalgal biomass when all bays and sampling periods were combined. These species formed the lower algal stratum--the understory. The understory also included Sphacelaria spp. (primarily S. arctica and S. plumosa), Chaetomorpha linum and C. melagonium, which together comprised 5.6% of macroalgal biomass, and a number of other species that were not weighed separately (2.1% of biomass).

The dominant canopy species at 3 m depth were Neodilsea integra (4.8% of total biomass), Fucus distichus (4.0%), Laminaria spp. (3.8%) and Chorda spp. (0.6%). Other less abundant canopy species were Devaleraea ramentaceum, Rhodomela confervoides, Punctaria glacialis and Desmarestia spp., which together comprised less than 3% of macroalgal biomass.

At 3 m depth, a zone with a relatively even and nearly complete cover of understory and canopy algae (see above) extended seaward for distances from 1 to 10 m. In each of the study bays there followed a kelp zone that was dominated by Laminaria saccharina, and also included L. solidungula, L. longicruris and Alaria sp. These large kelps were generally attached to small rocks or bivalve shells. In Bays 10 and 11, densities of kelp within this zone were high to depths of 3-5 m, and Laminaria spp. were present to a depth of 7 m. The width of the Laminaria zone was greatest in Bay 11, where the slope of the bottom was considerably less than in any other bay. In Bays

Table 20. Species list of benthic algae collected in four bays at Cape Hatt, northern Baffin Island, during August and September 1980, 1981 and 1982, and during August 1983.

Species and Authority
Chlorophyceae
Ulothrix flacca (Dilwyn) Thuret in LeJolis
Blidingia minima (Nageli ex Kützing) Kylin
Chlorochytrium schmitzii Rosenvinge
Chlorochytrium dermatocolax Reinke
Spongomorpha sonderi Kützing
Spongomorpha sp.
Chaetomorpha linum (O.F. Müller) Kützing
Chaetomorpha melagonium (Weber et Mohr) Kützing
Phaeophyceae
Pilayella macrocarpa Foslie
Pilayella littoralis (L.) Kjellman
Giffordia ovata (Kjellman) Kylin
Pseudolithoderma sp.
Myriactula lubrica (Rupr.) Jaasund
Symphyocarpus strangulans Rosenvinge
Eudesme virescens (Carmichael) J. Agardh
Phaeostroma pustulosum Kuckuck
Phaeostroma parasiticum Børgesen
Phaeostroma sp.
Elachistea lubrica Ruprecht
Stictyosiphon tortilis (Ruprecht) Reinke
Platysiphon verticillatus Wilce
Omphalophyllum ulvaceum Rosenvinge
Chordaria flagelliformis (O.F. Müller) C. Agardh
Delamarea attenuata (Kjellman) Rosenvinge
Dictyosiphon foeniculaceus (Hudson) Greville
Coelocladia arctica Rosenvinge
Desmarestia aculeata (L.) Lamouroux
Desmarestia viridis (O.F. Müller) Lamouroux
Punctaria glacialis Rosenvinge
Chorda filum (Linnaeus) Lamouroux
Chorda tomentosa Lyngbye
Agarum cribrosum (Mertens) Bory
Laminaria saccharina (L.) Lamouroux
Laminaria solidungula J. Agardh
Laminaria longicruris Pyl.
Haplospora globosa Kjellman
Sphacelaria plumosa Lyngbye
Sphacelaria arctica Harvey
Sphacelaria caespitula Lyngbye
Fucus distichus L. subsp. *evanescens* (C. Ag.) Powel
Rhodophyceae
Audouinella purpurea (Lightfoot) Woelkerling
Audouinella sp.
Ahnfeltia plicata (Hudson) Fries
Neodilsea integra (Kjellman) A. Zinova
Devaleraea ramentaceum (L.) Guiry
Palmaria palmata (L.) O. Kuntze
Polysiphonia arctica J. Agardh
Rhodomela confervoides (Hudson) Silva f. *flagellaris* Kjellman
Phyllophora truncata (Pallas) A. Zinova
Ptilota serrata Kützing
Odonthalia dentata (L.) Lyngbye
Harveyella mirabilis (Reinsch) Reinke
Halosacciocolax kjellmanii S. Lund
Pantoneura baerii (Postels et Ruprecht) Kylin
Antithamnion boreale (Gobi) Kjellman
Chrysophyceae
Phaeosaccion collinsii Farlow
Berkeleya rutilans (Trent.) Ep.
Navicula ramosissima (Agardh) Cleve
Nitzschia sp.
Coscinodiscus sp.

7 and 9, Laminaria spp. were much less abundant at 3-5 m, and kelps of any kind were relatively rare at depths >5 m.

A second kelp zone dominated by Agarum cribrosum occurred at depths >5 m, where A. cribrosum and Laminaria spp. were attached to sparsely distributed boulders and large rocks. Agarum cribrosum occurred to depths of at least 30 m in the study area (N. Snow, pers. comm.), and has been reported at depths exceeding 60 m in the Arctic (Wilce 1973). Many of the understory species present at 3 m also occurred at 7 m depth, but substrate cover was considerably less; Cross and Thomson (1981) estimated that percent cover of these algae was 68 to 90% at 3 m and 2 to 12% at 7 m depth. The large brown algae Desmarestia aculeata and D. viridis were also conspicuous along the deeper transects.

3.6.2 Biomass

Mean biomasses of total algae and of dominant species collected in airlift samples along transects at 3 m depth in each of the study bays and periods are shown in Appendix U. Mean biomass of total macroalgae was from 74.7 to 1032.6 g/m^2, depending on bay and period. These values (based on formalin-preserved wet weight) probably underestimate fresh weight; Thomson and Cross (1980) reported a considerable (>30%) formalin-induced reduction in the weight of understory algae from Cape Fanshawe, Bylot Island. Algal biomass at Cape Hatt (Appendix U) was higher than the biomass of macroalgae other than kelp at most of the 5 and 10 m stations in the Lancaster Sound area studied by Thomson and Cross (1980). However, kelp biomass in the Lancaster Sound area was considerably higher (0.5-12.7 kg/m^2 fresh wet weight) than our estimates of kelp biomass at Cape Hatt. The Cape Hatt data, however, were based on airlift samples from transects at 3 m depth (Laminaria spp., Appendix U), where kelp was represented primarily by plant fragments. Kelp biomass would have been much higher in the Laminaria zone that was observed at 3-5 m depth.

3.6.3 Distribution

Understory species tended to be more evenly distributed among bays than were the larger canopy species (Appendix U). Of the latter, Neodilsea integra was present in all bays but rarest in Bay 9; Laminaria spp. were rare in Bays 7 and 9; and Punctaria glacialis and Chorda spp. were absent or rare in Bay 11. Because of the relatively even distributions of understory algae and the dominance of the three understory species Stictyosiphon tortilis, Pilayella littoralis and Dictyosiphon foeniculaceus, detailed analysis was restricted to the biomasses of total algae and of these three species.

3.6.3.a Spatial and Temporal Effects

Results of analyses of variance for biomasses of total algae and dominant members of the understory community at 3 m depth are shown in Table 21. Differences among transects were significant for most variables, indicating considerable patchiness on a small (50 m) scale.

Bay and period effects were in most cases confounded by significant period x bay interactions in analysis of variance (Table 21). Bay effects were significant in the five cases where interpretation of main effects was possible. Biomass of Stictyosiphon tortilis was highest in Bay 11 (surface oil release), similar in Bays 7 (reference) and 10 (dispersed oil contamination), and lowest in Bay 9 (dispersed oil release). Total algal biomass was highest in Bays 10 and 11, intermediate in Bay 7, and lowest in Bay 9. Period effects were significant in only one of the five cases: total algal biomass increased progressively from August 1981 to September 1981 to August and September 1982 (biomass was similar in the last two periods).

3.6.3.b Oil Effects

Period x bay interaction effects were significant for Dictyosiphon foeniculaceus and Pilayella littoralis in all three types of analysis, and for total algal biomass in only one analysis type (Table 21). These interaction effects indicate the possibility of oil or dispersed oil effects. The interaction effect for total algal biomass was significant

Table 21. Three-factor analyses of variance for the biomass of macrophytic algae at 3 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. F-values are shown with significance levels (ns = F<0.05; * P<0.05; ** P<0.01; *** P<0.001).

Analysis	Taxon/df[3]	Source of Variation				
		Period	Bay	Period x Bay[4]	Transect (Bay)[3]	Per x Trans (Bay)[3]
Bays 9, 10, 11/ 1980–1982	Total algae	–[5]	–[5]	3.24 **	6.19 ***	1.22 ns
	Stictyosiphon tortilis	0.65 ns	7.23 *	0.53 ns	12.99 ***	1.70 *
	Dictyosiphon foeniculaceus	–[5]	–[5]	6.51 *	3.51 **	2.59 ***
	Pilayella littoralis + diatoms	–[5]	–[5]	3.78 **	5.40 ***	0.58 ns
	Degrees of freedom[3]	(4,6 or 30)	(2,6 or 30)	(8,6 or 30)	(6,311)	(24,311)
Bays 7, 9, 10, 11/ 1981, 1982	Total algae	7.19 ***	28.39 ***	1.79 ns	3.85 ***	1.17 ns
	Stictyosiphon tortilis	1.54 ns	7.82 **	0.33 ns	8.93 ***	1.65 *
	Dictyosiphon foeniculaceus	–[5]	–[5]	30.79 ***	0.79 ns	2.01 **
	Pilayella littoralis + diatoms	–[5]	–[5]	2.74 *	3.14 **	0.75 ns
	Degrees of freedom[3]	(3,8 or 32)	(3,8 or 32)	(9,8 or 32)	(8,333)	(24,333)
Bays 7, 9, 11/ 1981–1983	Total algae	1.17 ns	12.21 **	0.31 ns	8.64 ***	2.19 **
	Stictyosiphon tortilis	1.30 ns	8.68 *	0.14 ns	13.95 ***	2.02 **
	Dictyosiphon foeniculaceus	–[5]	–[5]	17.63 **	1.63 ns	2.73 ***
	Pilayella littoralis + diatoms	–[5]	–[5]	3.43 **	1.64 ns	0.78 ns
	Degrees of freedom[3]	(4,6 or 30)	(2,6 or 30)	(8,6 or 30)	(6,312)	(24,312)

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).
[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P<0.05), Transect (Bay) alone was used to test main effects.
[4] The Period x Bay term is the test of oil effects.
[5] Interpretation of main effects confounded by significant interaction of Period x Bay term.

only when Pre-spill Period 1 was considered, hence the source of interaction was the among-bay differences between pre-spill sampling periods; this is clearly not an oil effect. In the other two cases, inspection of the data (Fig. 28, Appendix U) shows that interactions are complex, and hence interpretation of the results is difficult.

3.6.3.b.i *Dictyosiphon foeniculaceus*

Biomass of *Dictyosiphon foeniculaceus* in Bay 11 was very low throughout the study period (Fig. 28), and within-bay variability was extremely high (Appendix U). Biomass in Bay 9 was only slightly higher, and the greatest temporal variability was that between the two pre-spill sampling periods. The most likely source of the bay x period interaction was the marked increase in biomass between 1981 and 1982 in Bays 7 and 10, in contrast with little or no change in Bays 9 and 11 (Fig. 28). *Dictyosiphon foeniculaceus* is a summer annual species (Wallentinus 1978), and most of the 1982 season's growth in Bays 7 and 10 apparently preceded the August sampling period. It is possible that this growth was stimulated by the low to moderate levels of oil that were present in the sediments of Bays 7 and 10 in (and presumably between) September 1981 and August 1982. To our knowledge, oil concentrations in sediments have not previously been related to algal growth; Shiels et al. (1973), however, reported photosynthetic stimulation in several species of macroalgae at low concentrations of oil in seawater (7 to 700 ppb).

Another possibility, however, is suggested by the high biomass of *Dictysiphon foeniculaceus* in Bay 10 during September 1980 and the low biomass of *D. foeniculaceus* in Bay 7 during August 1983 (Fig. 28). Together with 1981 and 1982 results, these data suggest that natural annual variability—not an 'oil effect'--is another possible explanation for the significant period x bay interaction in *D. foeniculaceus*.

3.6.3.b.ii *Pilayella littoralis*

Temporal changes in the biomass of *Pilayella littoralis* (+ tubular diatoms) were not consistent among bays; analysis results (Table 21) and inspection of the data (Fig. 28) suggest four possible sources of

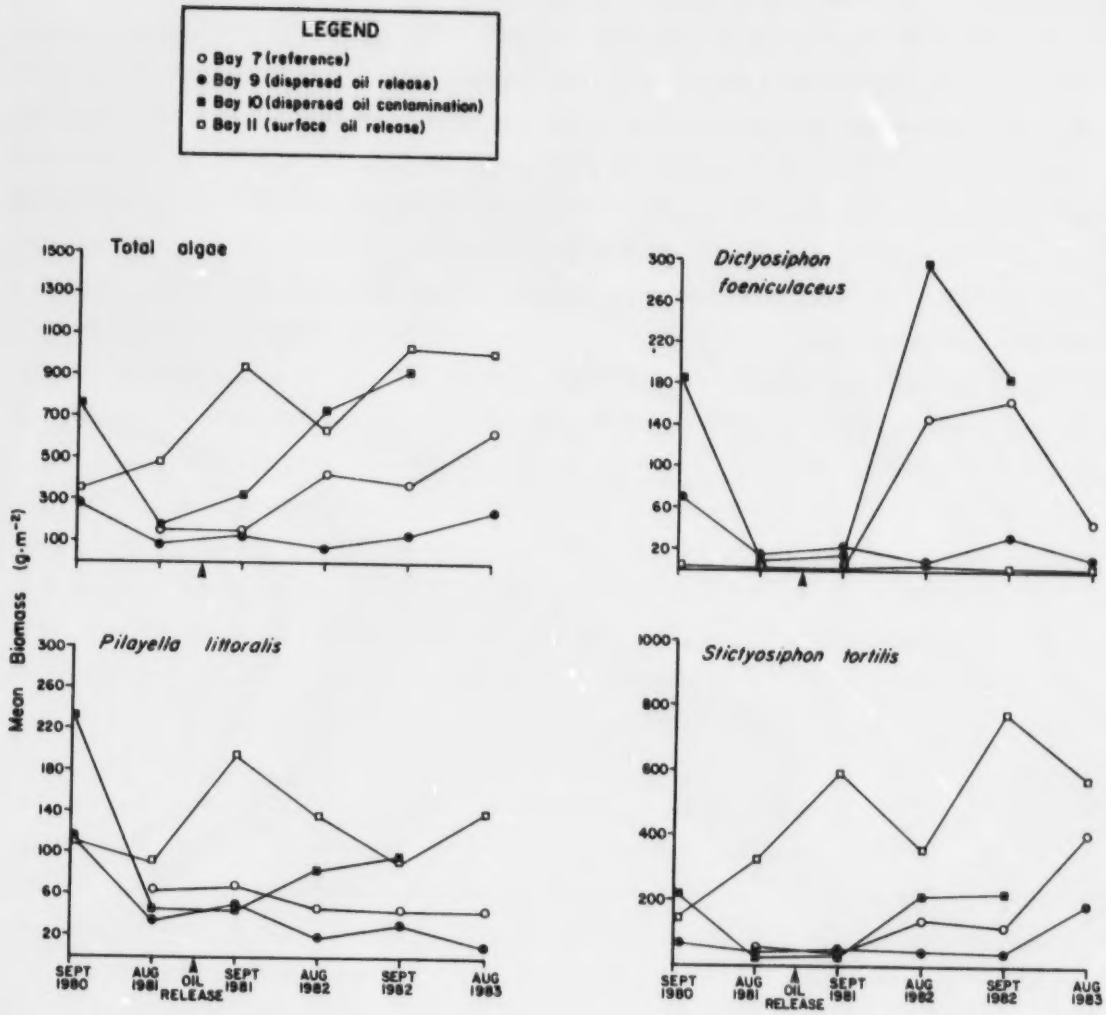


Figure 28. Mean biomass (formalin weight; g/m^2) of total algae and of dominant understory species at 3 m depth in four bays at Cape Hatt, northern Baffin Island, during pre- and post-spill sampling periods from September 1980 to August 1983. Data are expressed as the mean of 24 replicate 0.0625 m^2 airlift samples for each bay and period.

interaction. Between the two pre-spill sampling periods (September 1980 and August 1981) decreases in biomass were more pronounced in Bays 9 and 10 than in Bay 11. This was clearly not an oil effect, but represents natural temporal and/or spatial variation. The seemingly reduced biomass in Bay 9 in 1981 may represent spatial rather than temporal change. One transect stake in each of Bays 9 and 10 was lost between 1980 and 1981. Hence, locations sampled in 1981 may not have been exactly the same as in 1980. Inspection of the data (transect means) indicated that in Bay 9 some of the change was temporal (biomass decreased on each transect between 1980 and 1981) and that some was spatial (the amount of change was not consistent among transects). In Bay 10, however, the loss and replacement of the transect stake had no apparent effect (similar changes on all transects). Annual variability in growth may be a factor; P. littoralis is an annual species in the Arctic, first appearing in early summer in ice-free areas and becoming most abundant during August and September (Wilce 1973). At Cape Hatt, this species is part of a loose-lying population of algae (R.T. Wilce, pers. comm.); hence a second possibility is that the observed differences in abundance were attributable to among-bay differences in wave exposure or current regimes in combination with annual differences in oceanographic conditions.

During 1981, biomass in Bay 11 increased considerably between August and September, whereas in the other three bays biomass remained relatively constant. This is likely not an oil effect, as the oil released on the surface in Bay 11 did not penetrate below 1.5 m (Green et al. 1982), and oil was not incorporated into the sediment for several weeks (Boehm et al. 1982). Furthermore, it does not seem likely that any effect of either the surface or dispersed oil release would be detectable in 1981, as the majority of the summer growing season preceded contamination by oil.

Two other possible sources of interaction are (1) a decrease in biomass from August to September 1982 in Bay 11 relative to a slight increase or no change in the other bays, and (2) a biomass increase that occurred only in Bay 10 between September 1981 and August 1982. However, neither the decrease in biomass from August to September 1982 in Bay 11 nor the increase in biomass from September 1981 to August 1982 was significant (one-factor analyses of variance; $P>.07$).

In summary, no effects of oil were detected in data on biomasses of total algae or of two of the three species that were analyzed. In a third species, Dictyosiphon foeniculaceus, growth may have been stimulated by low levels of oil in sediments during the year following the oil releases, although natural annual variability was another possible explanation for the observed increases in biomass. Considerable amounts of oil were incorporated into 3 m sediments immediately after the dispersed oil release, and even greater quantities of oil originating from the 1981 oil releases were re-introduced into subtidal (3 m) sediments during the open water seasons of 1982 and 1983. However, neither oil in sediments nor oil in the water during the dispersed oil release had any detectable adverse effect on biomasses of the dominant understory algae at 3 m depth in the study area.

SECTION FOUR

SUMMARY AND CONCLUSIONS

The objectives of the macrobiological component of the BIOS project were to assess the effects of oil and dispersed oil on the macrophytic algae, the relatively immobile benthic infauna (e.g., bivalves, polychaetes), and the motile epibenthos (e.g., amphipods, urchins) in shallow arctic waters. Four bays at Cape Hatt, northern Baffin Island, were selected as experimental bays. During August 1981, 15 m^3 of Lagomedio crude oil was applied to the surface of one bay, and 15 m^3 of dispersed oil (10 Lagomedio : 1 Corexit 9527) was released underwater in another bay. The latter release also resulted in relatively heavy contamination of the third study bay, and low levels of contamination in the surface oil release bay and in the fourth (reference) bay. Systematic sampling was carried out in these bays during each of the two ice-free months (August and September) between September 1980 and August 1983.

Methods. -- To determine whether oil had an effect, we compared (1) temporal changes in the experimental (oil release) bays with temporal changes in the reference bay, and (2) temporal changes in the surface oil release bay with those in the dispersed oil bays. The analytical techniques employed were analysis of variance and analysis of covariance. In statistical terms, a significant interaction between spatial and temporal effects indicated a possible oil effect. The nature of each significant interaction was examined in relation to the type of oil treatment (surface vs. dispersed) and the concentrations of oil, both in the water during and immediately after the oil releases, and in the subtidal sediments during 1981 to 1983. Variables examined included density and biomass of dominant infaunal taxa, biomass of four infaunal feeding guilds and of dominant macroalgal species, density of epibenthic echinoderms and crustaceans, infaunal community structure, population structure in selected species of amphipods and bivalves, and size and weight-length relationships in common bivalve species.

Differences Among Bays and Sampling Periods. -- Most of the systematic variability identified by these analyses was spatial and temporal; little of the variation was attributable to oil effects. Nearly all variables differed significantly on small and large spatial scales (among-transects and among-bays, respectively). Significant temporal differences were less common and most often were annual rather than seasonal. There was some evidence of natural multi-year cycles in the nearshore marine benthic community.

Immediate Effects of Oil. -- Oil effects were visually apparent on the first and second days following both oil releases in 1981. Only intertidal amphipods and some larval fish were obviously affected by the surface oil release; immediate and one year post-spill effects on intertidal amphipods are reported by Cross (1982) and Cross and Martin (1983). The dispersed oil release, however, produced marked immediate effects on benthos at both 3 and 7 m depths in both the release bay and the adjacent bay (difference of approximately an order of magnitude in dispersed oil levels). In these bays, a variety of large infaunal and epibenthic invertebrates, particularly the bivalve Serripes groenlandicus, emerged from the substrate and/or assumed unnatural postures. There was evidence of recovery in these animals, however, within two weeks of the oil release.

Infauna. -- Inspection of the data and analysis results indicated that oil and dispersed oil released at Cape Hatt did not cause large-scale mortality of benthic biota or changes in community structure during the two post-spill years, probably because rather low concentrations of oil entered the sediments.

To test for subtle changes in infaunal density and biomass, we analyzed 28 species- or group-variables at 3 m depth, and 33 variables at 7 m depth. We found changes that might be related to oil in only one taxon at each of 3 and 7 m depths. The polychaete Spio spp. was apparently affected by oil in sediments at 3 m depth in both the dispersed oil release and surface oil release bays. Breeding in two-year-olds or development of their offspring in the fall and winter following the oil releasees was delayed in these two bays, whereas the year class that was produced in the oil release year was able to reproduce successfully (in 1982-1983) only in the reference bay. At

7 m depth, oil in the sediments of the surface oil release bay may have enhanced the settlement of juveniles of the bivalve genus Macoma in the summer of 1982, but the observed density increase was within the range of natural variability.

Data on mean size and population structure for four bivalve species and the holothurian Myriotrochus rinkii at Cape Hatt showed considerable spatial and temporal (seasonal and annual) variability. The only evidence of oil-related effects on size-frequency distribution was mortality of large Mya truncata at 3 m depth in Bay 11. The low numbers of individuals present, however, render this interpretation ambiguous. Most of the observed variability was likely attributable to natural variability (1) in recruitment of larvae with pelagic or direct development, (2) in growth rates, and/or (3) in mortality of young or old individuals.

Weight-length relationships in two of the four bivalve species examined were apparently affected by the experimental oil releases at Cape Hatt. In Macoma calcarea, the normal seasonal (August to September) increase in tissue weight relative to length occurred only in the reference bay. Macoma calcarea is a deposit feeder, and high concentrations of oil were accumulated in its body tissues from sediments in the oiled bays during the two weeks following the oil releases. In Serripes groenlandicus, tissue weight adjusted for length decreased progressively in the reference bay following the dispersed oil release. Serripes groenlandicus accumulated more oil in this bay than in any other, probably because its filtering activity was impaired in bays where dispersed oil concentrations were high.

It is not known whether the observed sublethal effects will have any long-term effects at the population or community levels. However, in the two years following the experimental oil releases such effects were not evident. Multivariate analysis techniques provided no evidence that oil or dispersed oil affected infaunal community composition or the abundances of dominant infaunal species assemblages. Infaunal community structure in the study area changed during the four years of study, but this temporal change was similar in each bay and at both depths studied. The interval of greatest change was between September 1981 and September 1982.

Analysis of biomasses of four feeding guilds (filter feeders, deposit feeders, surface deposit feeders and carnivores) showed that temporal changes in biomass were either lacking or were consistent among bays. Thus, there was no evidence that any particular feeding guild was especially sensitive to oil. Nearly all of the variation in the four infaunal feeding guilds was spatial. This spatial variability was evident on both small (transect) and larger (bay) scales, and in all four feeding guilds.

Epibenthos. -- We tested for subtle changes in densities of 11 subtidal epibenthic crustaceans at each of 3 and 7 m depths, and found changes that might be related to oil in only one taxon at 3 m depth. Length-frequency data provided more information on these density changes and indicated one other possible oil effect. In 1982, juveniles of the amphipod genus Anonyx apparently emigrated from 7 to 3 m depth earlier in the surface oil release bay than in the other bays. This may have been a behavioural response to the high levels of oil in the sediments of this bay. There was no indication that densities of the amphipod Pontoporeia femorata were affected by oil, but length-frequency data suggested that population structure was affected in the surface oil release bay. The scarcity of newly-released juveniles in this bay during August 1983 indicated that reproduction in the previous winter may have been adversely affected by oil in sediments. Thus there were indications that the surface oil release had a delayed effect on two subtidal amphipod species one or two years after the oil release. No effect of dispersed oil on epibenthic crustaceans was detected.

Cross and Martin (1983) reported effects of the oil releases at Cape Hatt on the density, biomass and population structure of Gammarus setosus in under-ice and intertidal habitats. Direct oiling of intertidal populations in Bay 11 caused immediate mortality, particularly in the 0+ year class. This cohort was almost absent from the under-ice surface in the following spring but was well represented in the intertidal habitat one year following the oil release. These individuals must have been recruited from adjacent areas. The release of Gammarus juveniles on the under-ice surface in Bay 11 was delayed in spring 1982, and the 0+ year class was reduced in size in the intertidal habitat during the following August and September. The dispersed

oil release, on the other hand, seems to have affected older Gammarus setosus (1 and 2+ year classes). Densities of these individuals were markedly reduced approximately one week following the release, but it is uncertain whether mortality or emigration was the cause of this decrease. Densities on the under-ice surface were low in both the pre- and the post-spill years. No effects of the dispersed oil release were apparent in abundance and population structure data collected in the intertidal habitat one year following the release.

The two large epibenthic echinoderms in the study area, Strongylocentrotus droebachiensis and Leptasterias polaris, were among the invertebrates that were apparently stressed immediately following the dispersed oil release. Analysis of density data showed no effect of dispersed oil on L. polaris, whereas effects on the density of S. droebachiensis were apparent. Urchins apparently emigrated actively from 7 m depth in the dispersed oil release bay to deeper, uncontaminated water. A movement from deep to shallow water in the adjacent bay may have occurred because dispersed oil entered that bay at a depth of approximately 8-10 m. In both bays, densities had returned to pre-spill levels within two weeks of the dispersed oil release. However, slightly reduced densities of urchins were found in 1983, possibly because of increased concentrations of oil in the sediments during 1983. The urchins probably emigrated to deeper water where sediments were cleaner.

Algae. -- Biomasses of the dominant understory algae at 3 m depth did not seem to be adversely affected by either oil in sediments or oil in the water during the dispersed oil release. No oil effects were detected in data on the biomasses of total algae or of two of the three species that were analyzed. In a third species, Dictyosiphon foeniculaceus, growth may have been stimulated by low levels of oil in sediments during the year following the oil releases, although natural annual variability was another possible explanation of the observed biomass increases.

Thus, oil and dispersed oil released at Cape Hatt caused some detectable effects on a small number of species, but did not cause large-scale mortality of benthic biota or any significant change in benthic infaunal community

structure during the two years following the releases. This lack of major effects was probably a result of the fact that hydrocarbon levels in the sediments were rather low, similar to those in 'lightly oiled' areas reported elsewhere. Significant oil effects were found in only 5 of 119 variables for which analyses were performed. Within the framework of published literature, our results are consistent with the low quantities of oil to which the animals were exposed.

Dispersed vs. Untreated Oil. -- The observed oil effects at Cape Hatt were associated with both untreated and chemically dispersed oil. The effects included sublethal effects and changes in abundance that were apparently caused by migration or reduced reproduction. Some of these effects appear to have been transitory, including immediate post-spill stress in a variety of benthic animals, temporary relocation of urchins, and changes in the abundance of amphipods. Other effects may persist or become more evident in subsequent years. These include changes in weight-length relationships in two bivalve species, and reduced reproduction in resident populations of amphipods and polychaetes that do not have planktonic larvae and, therefore, cannot recruit juveniles from the plankton.

Effects that may persist were found with both untreated and dispersed oil. Tissue weight in the deposit-feeding bivalve Macoma calcarea was adversely affected by high oil concentrations in sediments. In contrast, tissue weight in the filter-feeding Serripes groenlandicus was affected by low concentrations of dispersed oil in the water. Effects on reproduction of polychaetes and amphipods were apparently related to oil concentrations in sediments.

An important objective of the BIOS project was to compare oil effects in the dispersed oil release bay with those in the surface release bay and to make inferences about the effects of dispersing oil with chemical agents. To this end, it is possible to say that the effects of dispersed oil have occurred and that they were minor. Immediate post-spill effects were obvious but temporary and appear to have had no permanent effect. Medium-term effects did not change community composition and affected only a few species.

In the surface oil release bay, no immediate effects on subtidal benthos were obvious, and medium-term effects were similar to those resulting from the dispersed oil treatment. Most of the few species that were affected responded to both types of oil treatment, indicating that oil in sediments, regardless of its source, was responsible for the observed effects. Oil levels in the sediments of the study bays have not yet reached maximum levels (Boehm 1983) and resultant effects on the benthic community (if any) have yet to be manifested. The increasing concentrations of oil in sediments may be sufficient to cause a further change in condition orreproductive status of benthic animals, and possibly even mortality, in the next year or two.

SECTION FIVE

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APPENDIX A. Dates and locations (depth, bay, transect, and number of metres from N to S along the transect line) of each airlift sample collected at Cape Hatt, northern Baffin Island in 1980 (Pre-spill Period 1), 1981 (Pre-spill Period 2 and Post-spill Period 1), 1982 (Post-spill Periods 2 and 3) and 1983 (Post-spill Period 4).

Depth	Bay	Transect	Period	Replicate 1	2	3	4	5	6	7	8	Date(s)
7 m	7	1	Pre-2	2	6*	24	29	31*	36	39*	45	16 Aug
			Post-1	1*	4	11*	15	24*	33*	40*	42	3 Sept
			Post-2	5	7*	22	30	33	38*	40	46*	13 Aug
			Post-3	10	10*	26	35	36*	37	37*	42*	6 Sept
			Post-4	3	4*	21	29*	43*	46	49	49*	9 Aug
		2	Pre-2	0	19	30	31*	35	37	38*	49*	16 Aug
			Post-1	4*	10*	12*	26	28	36	46	48*	3 Sept
			Post-2	1	2	10	11*	14*	17*	31	42	13 Aug
			Post-3	4	8	12	16*	26*	42*	43*	47	6 Sept
			Post-4	0*	1*	3*	24*	31	33	38*	39	9 Aug
		3	Pre-2	5*	9	11*	15	20	22	27	36*	17 Aug
			Post-1	0	5	14	17*	25	25*	29*	48	3 Sept
			Post-2	2	4	4*	15*	19*	33	34	42	13 Aug
			Post-3	11	21*	22*	23*	24	28	36	44	6 Sept
			Post-4	2*	8	18	20*	21	42*	44*	45	9 Aug
	9	1	Pre-1	2	8*	20*	23*	31	35	36	43	1 Sept
			Pre-2	13	14	14*	18*	33	36	45*	48*	6 Aug
			Post-1	10*	16	20	24*	27*	37*	38	45	5 Sept
			Post-2	1	10	28	31*	34*	41*	43*	47	11 Aug
			Post-3	4	9*	12	17*	29*	34	35*	37	5 Sept
			Post-4	8	11	16*	19	25	38	40	40*	8 Aug
		2	Pre-1	6	24*	25	32*	37	43*	43	48	31 Aug, 1 Sept
			Pre-2	2*	8*	10	18*	27*	41	44	49	6, 7 Aug
			Post-1	3*	7	10*	12*	24	26	26*	42*	5 Sept
			Post-2	5	28	28*	30*	37*	40	46	46*	11 Aug
			Post-3	1*	4*	4	8	14*	16*	39	42	5 Sept
			Post-4	11	13*	14	16	22	33*	34	36*	8 Aug
		3	Pre-1	2	8*	20*	23*	31	35*	36*	43	31 Aug
			Pre-2	5*	10*	13*	14	17	20	34*	42	7 Aug
			Post-1	2*	7	18	19	25*	45*	46	47	5 Sept
			Post-2	0*	4*	21*	22*	23	25	44	49	11 Aug
			Post-3	0	1*	14*	16	18*	32*	44*	48	5 Sept
			Post-4	1	3	7*	8	16*	27	32	41*	8 Aug
	10	1	Pre-1	1	2*	7*	13*	14	16	29*	31	3 Sept
			Pre-2	6	9*	15	27	30	33	41*	48	13 Aug
			Post-1	19*	26	33*	39	40*	42	48*	50	6 Sept

Continued...

APPENDIX A Continued.

Depth	Bay	Transect	Period	Replicate 1	2	3	4	5	6	7	8	Date(s)
			Post-2	11*	23*	25*	28	35*	36	45*	49*	10 Aug
			Post-3	14	16	23*	25	28	35*	40*	48*	4 Sept
		2	Pre-1	5*	8	11	16*	20*	24	33*	41*	3 Sept
			Pre-2	4	10	13*	22	25	27	32	39*	13 Aug
			Post-1	5	15	15*	22*	24*	25*	26*	30*	6 Sept
			Post-2	8*	17	18	29	31	37	37*	46	10 Aug
			Post-3	0*	20	20*	35*	42	43	46*	49	4 Sept
		3	Pre-1	5	9	16*	20	24*	25	38*	44	3 Sept
			Pre-2	3	4*	10*	13*	31	39	45	48*	14 Aug
			Post-1	1	2*	10	18	24	39*	41*	43	6 Sept
			Post-2	1*	6	19*	23	27	32	34*	43*	10 Aug
			Post-3	1	9	10*	11*	17*	18	26*	41	4 Sept
7 m	11	1	Pre-1	1	5*	12*	23*	24	33	39*	40*	4, 5 Sept
			Pre-2	3	8	8*	12*	29*	35*	35*	39*	10 Aug
			Post-1	15	19	25	26	27*	30*	38*	42	1 Sept
			Post-2	0	2	4	7	11*	19*	22	35	8 Aug
			Post-3	6	6*	16	20*	23	38	46	49*	3 Sept
			Post-4	2*	5	12	20	30	36*	41*	47*	6 Aug
		2	Pre-1	6	12*	14*	16*	27*	29	40*	41	5, 6 Sept
			Pre-2	3*	6*	14	35	40	45	47*	48	12 Aug
			Post-1	3	3*	13*	18*	20	22*	30*	47*	1, 2 Sept
			Post-2	4*	10*	11*	15	19	24*	32*	49	8, 15 Aug
			Post-3	0	8	9*	20*	28	28*	31*	37	3 Sept
			Post-4	17*	18	19*	21*	29*	35*	39*	42*	6 Aug
		3	Pre-1	4*	20	25*	27	28	40	43*	45*	6 Sept
			Pre-2	4	6*	8*	14*	34*	35	36	48*	12 Aug
			Post-1	6	8	11	12*	13*	28	30	44	2 Sept
			Post-2	1*	7*	16*	18	23	30*	38	43	15 Aug
			Post-3	1	3	12*	25	31*	41	44*	45	3 Sept
			Post-4	5*	15	17*	18*	23*	24	41*	47*	6 Aug
3m	7	1	Pre-2	12	15*	24	27	33*	36	44	45	17 Aug
			Post-1	8	9	20	26*	34	39	39*	48*	5 Sept
			Post-2	16*	26	29*	33	40*	41	46*	47*	14 Aug
			Post-3	1*	3	5*	21*	22*	24*	29	31*	7 Sept
			Post-4	4	8*	17	17*	25	32*	35	43	10 Aug
		2	Pre-2	11	11*	16*	20	26	27	41	44	17 Aug
			Post-1	2*	3	6*	7*	33	36	37	49*	5 Sept
			Post-2	1	3*	4	9*	14	15	41*	46*	14 Aug

Continued...

APPENDIX A Continued.

Depth	Bay	Transect	Period	Replicate 1	2	3	4	5	6	7	8	Date(s)
			Post-3	1*	5*	10*	19*	21*	27*	28	37*	7 Sept
			Post-4	4	4*	5	12	26*	34	40	43*	10 Aug
		3	Pre-2	9	15*	17*	19	38	38*	39*	40*	17 Aug
			Post-1	2*	3	8*	10	16	20	27*	42*	5 Sept
			Post-2	0	2	11*	18*	24*	26	31	45*	14 Aug
			Post-3	18	21	28*	30	32*	33	40	48	7 Sept
			Post-4	0*	1*	4*	14	22	29*	35	44*	10 Aug
3 m	9	1	Pre-1	2*	5	10	11*	14	20	33	39*	10 Sept
			Pre-2	1	3	9	17	18*	23	32	39	7 Aug
			Post-1	4*	21	24*	29	32*	35*	43	49	6 Sept
			Post-2	4	18	22*	24	27*	35	37*	42	10 Aug
			Post-3	8	14	17	18	18*	19*	28*	33	5 Sept
			Post-4	5	6	8*	9*	11	19	27	48	9 Aug
		2	Pre-1	1*	9	10	17	24*	30	36	44	10 Sept
			Pre-2	7*	17*	23	24	32	38	45*	46	7, 8 Aug
			Post-1	14*	19	31*	38*	39	39*	40*	44	6 Sept
			Post-2	4	5	10*	18*	27	28	36*	46*	10, 11 Aug
			Post-3	1*	16	21*	28*	34	37	40	46	5 Sept
			Post-4	2	6	8*	9*	26	26*	42*	48*	9 Aug
		3	Pre-1	6*	16*	21	27	30*	33	38	45	10 Sept
			Pre-2	2*	5	8	12	15	45	45	48	7, 8 Aug
			Post-1	3*	8*	14	20*	23	40*	46	47	6 Sept
			Post-2	10*	17	21*	25	25*	32	36	42	11 Aug
			Post-3	11*	12	20	23*	27	37	38	43*	5 Sept
			Post-4	3	4*	9*	12*	29*	32*	33*	44*	9 Aug
	10	1	Pre-1	4*	11	30	33*	37*	43	45	46*	7 Sept
			Pre-2	1	5	12	13*	33	39*	42*	45*	14 Aug
			Post-1	0	7	14*	16*	17*	33*	34*	46	7 Sept
			Post-2	3*	12*	13	20	22*	41	44*	49	9 Aug
			Post-3	14	16	23*	25	25*	35*	40*	48*	6 Sept
		2	Pre-1	3*	6*	11	13	17*	32*	40	44	7 Sept
			Pre-2	2*	9*	10*	12*	13*	21*	24*	27*	14 Aug
			Post-1	3	4	11*	14	15	22*	34	37	7 Sept
			Post-2	9	18*	23	26	33*	35	41*	47	9 Aug
			Post-3	0*	20	20*	35*	42	43	46*	49	6 Sept
		3	Pre-1	2*	5*	8	13*	14	30	31	37*	8 Sept
			Pre-2	10	18*	20*	25	39	42	43	46	14 Aug
			Post-1	3	15	16*	24*	25*	27	38	41*	7 Sept

Continued...

APPENDIX A Concluded.

Depth	Bay	Transect	Period	Replicate 1	2	3	4	5	6	7	8	Date(s)
			Post-2	6	10*	19*	28*	36*	46*	47*	49	9 Aug
			Post-3	1	9	10*	11*	17*	18	26*	41	6 Sept
	11	1	Pre-1	0*	6*	12	16*	21	41	44	45*	9 Sept
			Pre-2	4	4*	8	11	18	20*	22*	33	12 Aug
			Post-1	6	15	23*	26	27*	36	37	42	2 Sept
			Post-2	0	1*	3	5	11*	25	35	45	9 Aug
			Post-3	5*	9	20	31*	40	41*	42	49*	3 Sept
			Post-4	12*	13*	16	27	28	29*	30*	46*	8 Aug
3 m		2	Pre-1	1*	12*	19*	26	27	30	39	47	9 Sept
			Pre-2	17	18	22	29*	31	32	33	40	12 Aug
			Post-1	10	25	30*	31*	37*	40	47*	48*	2 Sept
			Post-2	8	13	24	25	29	33*	35*	46*	9 Aug
			Post-3	1	9*	11	27*	28*	30*	32*	42*	3 Sept
			Post-4	0*	9	12	14*	17*	20*	24	35	8 Aug
		3	Pre-1	0	1*	6	7	14*	16*	18	42*	9 Sept
			Pre-2	1	9*	11*	25	26	30*	31	32	12 Aug
			Post-1	4	8	13*	17	19	23	35	39*	2 Sept
			Post-2	2*	3*	5*	10	11	13	29	37	9 Aug
			Post-3	4*	14	17*	21*	24	33	38*	43*	3 Sept
			Post-4	1*	3	7*	18*	23*	25*	36	39	8 Aug

* Indicates sample taken seaward of transect line.

APPENDIX B. Three-factor analyses of variance for penetration depth of airlift sampler in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. F-values are shown with significance levels (ns = $P>0.05$; * $P\leq0.05$; ** $P\leq0.01$; *** $P\leq0.001$) and degrees of freedom.

Analysis	Depth	Source of Variation				
		Period	Bay	Period x Bay	Transect (Bay)	Per x Trans (Bay)
Bays 9, 10, 11/ 1980-1982	3 m	_[3]	_[3]	2.36 * (8,30)	4.16 *** (6,311)	0.79 ns (24,311)
	7 m	2.42 ns (4,6)	0.23 ns (2,6)	0.49 ns (8,6)	4.32 *** (6,310)	2.76 *** (24,310)
Bays 7, 9, 10, 11/ 1981, 1982	3 m	_[3]	_[3]	2.31 * (9,32)	4.00 *** (8,332)	0.66 ns (24,332)
	7 m	2.04 ns (3,8)	0.72 ns (3,8)	0.73 ns (9,8)	3.80 *** (8,331)	2.10 ** (24,331)
Bays 7, 9, 11/ 1981-1983	3 m	3.75 * (4,30)	44.99 *** (2,30)	1.84 ns (8,30)	4.27 *** (6,313)	0.70 ns (24,313)
	7 m	3.49 ns (4,6)	0.68 ns (2,6)	0.78 ns (8,6)	2.51 * (6,313)	2.00 ** (24,313)

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

[3] Interpretation of main effects confounded by significant interaction of Period x Bay term.

APPENDIX C. List of species of benthic fauna collected by airlift at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983.

ANTHOZOA

Unidentified Anthozoa

NEMERTINEA

Unidentified Nemertinea

NEMATODA

Unidentified Nematoda

POLYCHAETA

Ampharete arctica
Ampharete acutifrons
Ampharete spp.
Amphicteis sundevalli
Amphitrite cirrata
Antinoella sarsi
Apistobranchus tullbergi
Aricidea hartmanae
Asabellides sibirica
Axionica sp.
Axiothella catenata
Brada granulata
Brada inhabilis
Brada villosa
Capitella capitata
Chaetozone setosa
Chone infundibuliformis
Cirratulidae spp.
Cirratulus cirratus
Cossura longocirrata
Diplocirrus hirsutus
Diplocirrus longisetosus
Dysponetus pygmaeus
Ephesiella minuta
Eteone barbata
Eteone longa
Euchone analis
Exogone verrugera
Gattyana cirrhosa
Glycera capitata
Harmothoe extenuata
Harmothoe imbricata
Lanassa nordenskioldi
Laonome kroyeri
Laphania boecki
Lasaea abranchiata
Lumbrinereis impatiens
Lumbrinereis minuta
Lysilla loveni
Maldane sarsi
Mediomastus sp.
Melaenis loveni
Myriochele oculata
Neosamphitrite sp.
Nephtys ciliata
Nereimyra punctata
Nereis zonata
Nicolea sp.
Nicomache lumbricalis
Ophelia limacina
Ophelina acuminata
Ophryotrocha puerilis
Oriopsis crenicollis
Owenia fusiformis
Paraonis sp.
Pectinaria granulata
Pectinaria hyperborea
Petaloproctus tenuis
Pholoe minuta
Phyllodoce citrina
Phyllodoce groenlandica
Phyllodoce mucosa
Pionosyllis compacta
Pista cristata
Pista maculata
Polycirrus sp.
Polydora quadrilobata
Potamilla neglecta
Praxillella praetermissa
Prionospio steenstrupi
Proclea graffi
Pygospio elegans
Rhodine loveni
Scalibregma inflatum
Scoloplos armiger
Scoloplos pugettensis
Sphaerodoropsis biserialis
Sphaerodoropsis minuta
Spio spp.
Spirorbis spp.
Syllidae sp.
Terebellides stroemi
Tharyx marioni
Thelepus cincinnatus
Travisia forbesi
Trichobranchus glacialis
Unidentified Polychaeta

GASTROPODA

Acmaea rubella
Acmaea testudinalis
Admete couthouyi
Alvania mighelsi
Alvania sp.
Beringius sp.
Buccinum ciliatum
Buccinum cf. scalariforme
Buccinum cyaneum
Buccinum sericatum
Cingula castanea
Colus islandicus
Colus cf. spitzbergensis
Colus tortuosus
Frigidoalvania cruenta
Lunatia pallida
Margarites groenlandicus
Margarites helicinus
Margarites umbilicalis
Moelleria costulata
Natica clausa
Oenopota arctica
Oenopota cf. bicarinata
Oenopota cf. cineres
Oenopota incisula
Oenopota pyramidalis
Oenopota turricula
Oenopota spp.
Onoba aculeus
Philine lima
Propebela turricula
Retusa obtusa
Scaphander punctostriatus
Trichotropis borealis
Unidentified Gastropoda

POLYPLACOPHORA

Tonicella marmorea

BIVALVIA

Astarte borealis
Astarte montagui
Clinocardium ciliatum
Hiatella arctica
Lyonsia arenosa
Macoma calcarea
Macoma loveni
Macoma moesta
Musculus discors
Musculus niger
Mya truncata
Mytilus edulis
Nucula belloti
Nuculana minuta

Continued...

APPENDIX C. Concluded.

Nuculana pernula
Periploma sp.
Serripes groenlandicus
Thracia sp.
Thyasiridae spp.
Yoldiella sp.
Unidentified Bivalvia

PYCNOGONIDA

Unidentified Pycnogonida

CUMACEA

Brachydiastylis resima
Brachydiastylis sp.
Campylaspis rubicunda
Diastylis dalli
Diastylis edwardsi
Diastylis lepichini
Diastylis lucifera
Diastylis rathkei
Eudorella hirsuta
Leptostylis macrura
Leucon nasica
Leucon nasicoides
Leucon pallidus
Leucon sp.

OSTRACODA

Eucytheridae bradii
Eucytheridae punctillata
Finmarchinella finmarchica
Philomedes globosa
Rabilimis mirabilis

AMPHIPODA

Ampelisca macrocephala
Anonyx laticoxae
Anonyx nugax
Anonyx sarsi
Apherusa borealis
Apherusa glacialis
Apherusa megalops
Atylus carinatus
Bathymedon longimanus
Bathymedon obtusifrons
Boeckosimus plautus
Byblis gaimardi
Centromedon pumilus
Corophium clarencense
Gammaracanthus loricatus
Gammarus setosus
Gammarus wilkitzkii
Guernea nordenskioldi
Haploops laevis
Harpinia serrata
Ischyrocerus sp.
Melita dentata
Metopa sp.
Metopella carinata
Monoculodes borealis
Monoculodes kroyeri
Monoculodes latimanus
Monoculodes longirostris
Monoculodes schneideri
Monoculodes sp.
Monoculopsis longicornis
Oediceros saginatus
Onisimus glacialis
Onisimus litoralis
Onisimus nanseni
Opisa eschrichti
Orchomene minuta
Parapleustes gracilis
Paroediceros lynceus
Photis reinhardi
Phoxocephalus holbolli
Pleustidae spp.
Pleusymtes glaber
Pontogeneia inermis
Pontoporeia femorata
Protomedia fasciata
Stenothoidae spp.
Tmetonyx sp.
Westwoodilla brevicalcar
Westwoodilla megalops
Weyprechtia pinguis
Unidentified Amphipoda

DECAPODA

Argis dentata
Lebbeus microceros
Lebbeus polaris
Pasiphaeidae spp.
Sabinea sarsii
Sclerocrangon boreas
Sclerocrangon ferox
Spirontocaris phippsi

OTHER CRUSTACEA

Unidentified Mysidacea
Unidentified Nebaliacea
Unidentified Tanaidacea
Unidentified Isopoda

ASTEROIDEA

Leptasterias groenlandica
Leptasterias polaris
Stephanasterias albula

OPHIUROIDEA

Amphiura peilopora
Amphiura sundevalli
Ophiocten sericeum
Ophiopus arcticus
Ophiura robusta
Ophiura sarsi

ECHINOIDEA

Strongylocentrotus droebachiensis

HOLOTHUROIDEA

Myriotrochus rinkii

ASCIDIACEA

Rhizomolgula globularis
Unidentified Ascidiacea

OTHER PHYLA

Priapulus bicaudatus
Priapulus caudatus
Unidentified Echiura
Unidentified Sipuncula

PISCES

Artediellis uncinatus
Boreogadus saida
Eumesogrammus praecisus
Eumicrotremus spinosus
Eumicrotremus sp.
Gadus ogac
Gymnelis viridis
Gymnocanthus tricuspis
Icelus spatula
Leptoclinus maculatus
Liparis tunicatus
Lycodes mucosus
Myoxocephalus quadricornis
Myoxocephalus scorpioides
Myoxocephalus scorpius
Triglops pingelii

Appendix D. Mean density (no./m²) of major taxa and selected species of infauna in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Data are expressed as mean ± standard deviation and are based on 8 replicate 0.0625 m² airlift samples on each of three transects for each depth, period and bay.

Taxon	Period[2]	3 m Depth				7 m Depth			
		Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Total infauna[3]	Pre-spill 1	-	3980.7 ± 1024.7	3288.0 ± 1323.6	1487.3 ± 911.4	-	3706.0 ± 1258.9	3020.7 ± 919.6	3045.3 ± 605.8
	Pre-spill 2	1753.3 ± 881.5	3977.3 ± 1759.5	2459.7 ± 786.0	1118.8 ± 561.3	2552.7 ± 786.9	3436.7 ± 973.4	2445.9 ± 638.6	2827.3 ± 851.8
	Post-spill 1	1994.7 ± 1020.8	4701.3 ± 2095.3	2637.3 ± 850.3	1404.5 ± 782.1	2773.3 ± 649.4	3275.3 ± 776.6	2822.8 ± 660.0	2791.2 ± 1052.6
	Post-spill 2	2895.3 ± 844.4	4879.3 ± 1931.7	3085.7 ± 1148.6	1495.0 ± 599.7	2936.4 ± 1154.4	4563.3 ± 1533.6	3448.0 ± 1366.6	3347.5 ± 956.6
	Post-spill 3	2962.7 ± 983.4	5296.7 ± 1890.8	2864.0 ± 1118.3	1622.4 ± 1054.9	3367.3 ± 1468.8	4419.3 ± 1499.8	3291.0 ± 946.3	4086.7 ± 1270.9
	Post-spill 4	6082.2 ± 3014.9	6598.0 ± 2136.2	-	2303.6 ± 1097.2	3615.3 ± 1073.8	4995.3 ± 2487.5	-	7485.0 ± 1265.2
Polychaeta	Pre-spill 1	-	2045.3 ± 585.3	1746.0 ± 743.4	893.3 ± 507.1	-	920.0 ± 343.1	988.7 ± 333.5	971.3 ± 267.5
	Pre-spill 2	865.3 ± 522.9	1916.0 ± 838.3	1479.0 ± 545.3	779.0 ± 369.4	786.7 ± 302.1	1006.7 ± 392.1	795.8 ± 291.5	982.0 ± 335.2
	Post-spill 1	1052.7 ± 646.9	1986.0 ± 805.1	1496.7 ± 556.6	898.5 ± 511.4	804.7 ± 288.6	1028.7 ± 325.0	1171.5 ± 533.5	715.4 ± 287.0
	Post-spill 2	1433.0 ± 502.0	2303.3 ± 899.9	1852.3 ± 592.8	1105.3 ± 497.5	866.4 ± 376.3	1448.0 ± 643.2	1488.1 ± 608.4	1083.0 ± 409.7
	Post-spill 3	1865.3 ± 601.2	2876.0 ± 1152.1	1656.3 ± 805.4	1273.2 ± 864.2	1153.3 ± 531.5	1592.0 ± 552.4	1356.6 ± 537.4	1720.7 ± 998.4
	Post-spill 4	4487.1 ± 2798.1	3594.0 ± 1099.2	-	1731.8 ± 973.0	1653.3 ± 651.9	2509.3 ± 2456.9	-	1720.0 ± 808.2
Pholoe minuta	Pre-spill 1	-	346.7 ± 254.5	303.3 ± 251.9	228.0 ± 226.1	-	408.7 ± 234.8	390.7 ± 235.4	283.3 ± 200.3
	Pre-spill 2	316.0 ± 350.0	834.0 ± 652.1	297.0 ± 162.3	164.7 ± 164.6	339.3 ± 163.8	451.3 ± 244.3	317.9 ± 175.4	258.7 ± 141.9
	Post-spill 1	322.0 ± 296.8	798.3 ± 455.4	337.3 ± 224.8	207.4 ± 230.4	376.0 ± 193.9	530.0 ± 203.4	498.5 ± 303.5	253.5 ± 136.1
	Post-spill 2	459.4 ± 267.8	822.7 ± 397.3	367.4 ± 226.3	171.5 ± 119.1	330.1 ± 180.6	604.7 ± 265.7	687.9 ± 417.6	347.8 ± 204.9
	Post-spill 3	444.0 ± 342.0	840.0 ± 416.8	302.9 ± 239.7	196.4 ± 233.7	396.0 ± 227.0	740.7 ± 299.9	514.6 ± 230.6	396.7 ± 130.1
	Post-spill 4	991.6 ± 491.7	1274.0 ± 538.1	-	525.8 ± 332.4	803.3 ± 395.6	1060.7 ± 295.8	-	516.3 ± 282.2
Nereimyra punctata	Pre-spill 1	-	290.7 ± 351.4	610.0 ± 451.1	286.0 ± 266.1	-	2.7 ± 6.1	40.7 ± 50.6	42.7 ± 166.6
	Pre-spill 2	235.3 ± 200.1	183.3 ± 193.8	477.7 ± 372.1	282.8 ± 252.5	14.7 ± 20.0	6.7 ± 11.5	38.0 ± 38.5	6.7 ± 8.1
	Post-spill 1	207.3 ± 240.1	130.0 ± 159.8	381.3 ± 325.7	234.3 ± 180.6	32.0 ± 42.2	6.7 ± 9.3	58.8 ± 76.4	4.9 ± 14.0
	Post-spill 2	318.8 ± 150.3	207.3 ± 178.4	344.9 ± 224.6	208.5 ± 105.6	13.3 ± 23.9	16.0 ± 17.0	92.7 ± 155.5	14.4 ± 34.5
	Post-spill 3	326.0 ± 166.7	230.7 ± 157.3	209.8 ± 125.1	266.7 ± 227.3	32.7 ± 58.5	12.7 ± 14.1	46.9 ± 60.7	19.3 ± 39.2
	Post-spill 4	340.5 ± 142.0	344.7 ± 305.4	-	372.8 ± 354.6	17.3 ± 29.4	42.0 ± 49.0	-	10.6 ± 23.8
Euchone analis	Pre-spill 1	-	466.7 ± 490.2	142.7 ± 139.1	80.7 ± 96.8	-	4.7 ± 13.7	6.0 ± 14.8	12.7 ± 33.4
	Pre-spill 2	63.3 ± 66.0	346.7 ± 275.6	107.8 ± 75.4	23.3 ± 41.7	10.7 ± 20.4	10.0 ± 17.5	14.6 ± 27.7	7.3 ± 11.5
	Post-spill 1	149.3 ± 188.1	427.3 ± 303.7	173.3 ± 161.0	21.6 ± 34.3	8.7 ± 11.5	19.3 ± 29.1	9.3 ± 16.3	2.1 ± 5.5
	Post-spill 2	162.2 ± 146.9	563.3 ± 622.1	181.5 ± 121.6	41.3 ± 54.6	44.9 ± 109.7	29.3 ± 31.5	16.7 ± 23.3	8.7 ± 21.1
	Post-spill 3	208.7 ± 213.9	770.7 ± 808.5	201.7 ± 256.8	53.1 ± 91.3	39.3 ± 86.0	32.7 ± 46.3	35.3 ± 123.9	23.3 ± 47.6
	Post-spill 4	1092.0 ± 1468.7	823.3 ± 705.2	-	68.5 ± 101.0	7.3 ± 13.3	24.7 ± 34.0	-	7.3 ± 18.9
Spio spp.	Pre-spill 1	-	6.0 ± 12.3	4.0 ± 9.7	3.3 ± 6.6	-	12.0 ± 13.6	45.3 ± 27.4	17.3 ± 18.8
	Pre-spill 2	10.0 ± 20.5	2.7 ± 6.1	3.5 ± 8.3	5.3 ± 13.9	10.0 ± 15.5	16.7 ± 19.2	32.7 ± 27.5	16.0 ± 26.3
	Post-spill 1	22.0 ± 33.0	2.7 ± 7.7	11.3 ± 19.7	9.4 ± 26.9	14.7 ± 15.6	10.7 ± 14.7	64.8 ± 58.9	3.5 ± 10.7
	Post-spill 2	178.5 ± 124.1	14.0 ± 21.8	125.8 ± 179.1	33.1 ± 46.0	18.7 ± 23.4	44.7 ± 36.2	88.7 ± 72.6	28.7 ± 38.0
	Post-spill 3	366.0 ± 238.3	177.3 ± 171.9	256.8 ± 230.1	146.9 ± 140.3	44.0 ± 42.0	111.3 ± 146.1	154.0 ± 128.5	96.7 ± 92.0
	Post-spill 4	1087.8 ± 965.4	181.3 ± 158.2	-	68.9 ± 80.3	102.7 ± 120.2	99.3 ± 77.4	-	45.3 ± 56.4
Eteone longa	Pre-spill 1	-	88.7 ± 71.6	110.7 ± 103.3	93.3 ± 83.8	-	12.0 ± 13.6	21.3 ± 18.1	31.3 ± 18.6
	Pre-spill 2	55.3 ± 49.5	42.0 ± 28.6	135.5 ± 207.4	104.2 ± 65.7	25.3 ± 47.6	14.7 ± 17.0	22.3 ± 15.8	25.3 ± 22.1
	Post-spill 1	71.3 ± 64.7	70.7 ± 68.0	74.7 ± 60.9	201.3 ± 196.5	22.7 ± 27.5	12.7 ± 17.6	28.0 ± 26.4	21.5 ± 27.1
	Post-spill 2	76.0 ± 59.5	62.7 ± 40.8	96.7 ± 91.1	118.0 ± 118.1	14.7 ± 15.6	12.7 ± 14.1	25.3 ± 24.0	30.7 ± 25.4
	Post-spill 3	82.0 ± 68.3	71.3 ± 49.3	85.4 ± 60.8	137.3 ± 136.0	34.0 ± 33.5	15.3 ± 15.3	27.0 ± 17.6	31.3 ± 29.3
	Post-spill 4	102.7 ± 72.5	64.7 ± 41.0	-	175.6 ± 155.4	34.0 ± 30.3	20.7 ± 18.6	-	42.6 ± 57.5
Chaetozone setosa	Pre-spill 1	-	105.3 ± 92.3	148.7 ± 197.5	50.0 ± 63.2	-	23.3 ± 41.7	4.7 ± 11.0	12.7 ± 52.1
	Pre-spill 2	0.7 ± 3.3	68.7 ± 79.2	92.5 ± 95.4	22.8 ± 30.8	0	24.7 ± 25.8	2.1 ± 7.3	0.7 ± 3.3
	Post-spill 1	2.7 ± 10.2	81.3 ± 79.4	127.3 ± 155.3	19.5 ± 40.6	0	24.0 ± 30.9	6.0 ± 10.4	0
	Post-spill 2	15.3 ± 27.3	135.3 ± 134.2	200.9 ± 219.3	77.3 ± 120.6	3.3 ± 16.3	60.0 ± 66.4	4.7 ± 17.0	0
	Post-spill 3	15.3 ± 37.3	131.3 ± 152.4	180.3 ± 178.8	30.7 ± 55.2	0.7 ± 3.3	48.0 ± 46.5	6.0 ± 20.5	2.0 ± 5.4
	Post-spill 4	3.3 ± 10.5	186.7 ± 137.7	-	62.7 ± 148.7	0.7 ± 3.3	56.7 ± 44.3	-	3.3 ± 10.5
Capitella capitata	Pre-spill 1	-	58.7 ± 161.8	38.3 ± 37.4	20.7 ± 28.5	-	15.3 ± 27.7	31.3 ± 67.1	11.3 ± 14.5
	Pre-spill 2	32.7 ± 36.4	34.7 ± 60.9	54.9 ± 70.0	19.0 ± 28.7	20.0 ± 29.2	14.7 ± 36.8	10.4 ± 13.3	21.3 ± 32.9
	Post-spill 1	22.0 ± 30.9	19.3 ± 35.3	46.0 ± 77.4	9.7 ± 12.5	10.0 ± 14.8	9.3 ± 13.3	17.3 ± 23.6	8.3 ± 10.6
	Post-spill 2	48.0 ± 99.6	28.0 ± 51.7	77.5 ± 81.3	36.7 ± 75.1	18.0 ± 34.6	22.0 ± 27.0	49.6 ± 144.2	18.7 ± 23.9
	Post-spill 3	56.0 ± 79.9	20.0 ± 28.4	64.0 ± 69.5	128.5 ± 346.4	28.7 ± 27.1	41.3 ± 50.8	20.6 ± 33.0	33.3 ± 35.9
	Post-spill 4	68.7 ± 121.6	18.0 ± 30.3	-	60.8 ± 70.7	80.0 ± 190.5	531.3 ± 2419.2	-	20.6 ± 35.1
Pectinaria granulata	Pre-spill 1	-	30.7 ± 25.4	22.0 ± 27.4	13.3 ± 19.3	-	45.3 ± 39.7	89.3 ± 41.1	61.3 ± 31.6
	Pre-spill 2	15.3 ± 18.0	38.0 ± 25.8	18.1 ± 35.2	6.0 ± 10.4	62.0 ± 45.3	63.3 ± 37.9	68.9 ± 47.6	49.3 ± 29.1
	Post-spill 1	10.7 ± 12.2	23.3 ± 24.5	22.7 ± 29.1	4.9 ± 10.2	50.7 ± 35.2	55.3 ± 34.0	64.0 ± 46.5	54.6 ± 47.7
	Post-spill 2	16.0 ± 25.4	36.7 ± 50.9	24.7 ± 35.6	6.7 ± 10.5	42.7 ± 38.8	45.3 ± 32.9	66.7 ± 41.8	47.3 ± 29.3
	Post-spill 3	8.7 ± 13.3	25.3 ± 30.5	19.3 ± 21.1	9.3 ± 15.6	48.7 ± 37.3	56.7 ± 34.0	68.0 ± 49.1	60.7 ± 32.0
	Post-spill 4	16.0 ± 19.5	28.0 ± 27.6	-	10.7 ± 11.2	50.0 ± 49.1	57.3 ± 35.0	-	50.0 ± 26.0

Continued...

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).
[3] All taxa but nemerteans and epibenthic crustaceans and echinoderms.

Appendix D. Continued.

Taxon	Period[2]	3 m Depth				7 m Depth			
		Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Praetilella praetermissa	Pre-spill 1	-	18.7 ± 19.8	27.3 ± 50.3	0.7 ± 3.3	-	40.0 ± 30.9	40.0 ± 31.3	56.0 ± 44.5
	Pre-spill 2	4.7 ± 11.0	34.7 ± 62.2	23.0 ± 31.6	0	18.7 ± 19.3	42.7 ± 37.9	28.5 ± 18.0	48.7 ± 31.1
	Post-spill 1	14.0 ± 23.7	38.7 ± 51.0	46.7 ± 59.7	0.7 ± 3.3	19.3 ± 20.6	40.0 ± 24.5	38.7 ± 34.0	60.9 ± 49.5
	Post-spill 2	18.7 ± 36.7	35.3 ± 36.5	82.7 ± 101.1	1.3 ± 4.5	24.0 ± 14.2	60.7 ± 46.0	51.3 ± 52.3	60.7 ± 42.5
	Post-spill 3	8.0 ± 13.3	38.7 ± 36.5	48.8 ± 76.8	0	48.0 ± 30.6	60.0 ± 46.0	60.0 ± 38.7	96.7 ± 68.2
	Post-spill 4	36.2 ± 72.3	50.7 ± 60.0	-	1.3 ± 4.5	53.3 ± 43.7	67.3 ± 52.7	-	86.0 ± 61.7
Haldane sarsi	Pre-spill 1	-	0	0	0	-	32.7 ± 80.7	22.0 ± 37.7	100.0 ± 116.5
	Pre-spill 2	0	0	0	0.7 ± 3.3	30.7 ± 53.6	26.0 ± 36.8	15.3 ± 17.0	114.7 ± 130.5
	Post-spill 1	0.7 ± 3.3	0	0	0	25.3 ± 33.7	16.7 ± 27.7	28.0 ± 40.7	68.5 ± 74.1
	Post-spill 2	0	0.7 ± 3.3	0	0	30.0 ± 38.7	25.3 ± 40.3	35.3 ± 54.2	82.7 ± 96.4
	Post-spill 3	0	0	0.7 ± 3.3	0	49.3 ± 108.2	32.7 ± 43.6	13.3 ± 32.9	58.7 ± 66.7
	Post-spill 4	0	0	-	0	70.0 ± 71.8	22.0 ± 33.3	-	100.0 ± 119.4
Bivalvia	Pre-spill 1	-	1160.7 ± 639.2	1022.7 ± 616.8	317.3 ± 300.5	-	2458.0 ± 852.7	1456.0 ± 766.3	1732.0 ± 496.0
	Pre-spill 2	299.3 ± 208.7	1250.7 ± 863.9	633.6 ± 257.6	144.7 ± 211.4	1406.0 ± 692.7	2130.0 ± 667.5	1469.7 ± 643.4	1608.7 ± 540.0
	Post-spill 1	276.7 ± 205.5	1637.3 ± 1080.6	676.0 ± 328.9	260.9 ± 260.4	1614.0 ± 636.2	1970.7 ± 560.6	1476.0 ± 586.2	1686.6 ± 703.9
	Post-spill 2	364.0 ± 221.6	1348.7 ± 810.6	701.8 ± 428.5	164.0 ± 187.8	1652.0 ± 931.5	2693.3 ± 950.0	1491.3 ± 890.6	1760.7 ± 592.8
	Post-spill 3	271.3 ± 215.4	1374.7 ± 739.2	613.3 ± 353.2	162.5 ± 320.0	1791.3 ± 1057.7	2688.3 ± 961.5	1701.8 ± 673.4	1876.7 ± 585.5
	Post-spill 4	459.3 ± 317.4	1706.0 ± 1116.6	-	167.7 ± 125.7	1541.3 ± 621.9	2157.3 ± 807.5	-	1776.0 ± 684.4
Mya truncata	Pre-spill 1	-	278.0 ± 160.1	226.0 ± 215.7	57.3 ± 58.5	-	185.3 ± 87.9	161.3 ± 95.2	202.7 ± 96.9
	Pre-spill 2	58.0 ± 42.4	258.0 ± 161.4	136.3 ± 80.8	24.7 ± 43.7	128.7 ± 75.9	121.3 ± 74.1	102.3 ± 51.9	190.0 ± 105.3
	Post-spill 1	77.3 ± 62.4	299.3 ± 189.2	124.0 ± 70.5	30.6 ± 51.7	121.3 ± 67.9	103.3 ± 56.8	106.0 ± 53.1	172.5 ± 89.6
	Post-spill 2	80.0 ± 65.9	263.3 ± 211.0	95.2 ± 73.8	17.3 ± 29.1	108.3 ± 56.7	128.0 ± 81.6	98.7 ± 82.4	172.0 ± 90.3
	Post-spill 3	58.3 ± 44.6	272.7 ± 216.0	110.0 ± 87.0	25.9 ± 56.4	147.3 ± 89.5	142.7 ± 86.1	138.3 ± 93.6	185.3 ± 101.1
	Post-spill 4	96.7 ± 62.8	260.7 ± 188.2	-	22.8 ± 33.0	106.7 ± 45.0	117.3 ± 62.9	-	157.3 ± 85.0
Thysanidae spp.	Pre-spill 1	-	243.3 ± 255.5	126.0 ± 90.3	9.3 ± 23.1	-	662.7 ± 269.8	506.7 ± 268.3	81.3 ± 88.5
	Pre-spill 2	20.7 ± 33.2	204.0 ± 179.8	91.0 ± 65.8	2.7 ± 7.7	412.7 ± 241.4	693.3 ± 228.5	444.5 ± 272.7	77.3 ± 72.6
	Post-spill 1	37.3 ± 46.6	296.0 ± 380.9	126.0 ± 76.2	12.5 ± 43.7	496.7 ± 261.6	602.7 ± 202.1	436.7 ± 221.2	99.5 ± 171.9
	Post-spill 2	41.3 ± 50.4	206.7 ± 151.3	132.7 ± 123.3	0.7 ± 3.3	505.3 ± 356.6	959.3 ± 363.5	581.3 ± 344.2	87.3 ± 73.6
	Post-spill 3	17.3 ± 20.5	268.7 ± 202.6	130.7 ± 116.9	0.7 ± 3.3	588.7 ± 416.1	934.7 ± 413.4	547.1 ± 245.2	88.0 ± 69.2
	Post-spill 4	57.3 ± 96.9	328.7 ± 413.1	-	0	604.0 ± 359.9	807.3 ± 379.2	-	87.3 ± 73.8
Astarte borealis	Pre-spill 1	-	192.0 ± 156.0	32.0 ± 41.9	21.3 ± 30.8	-	437.3 ± 257.2	368.0 ± 207.7	384.0 ± 206.0
	Pre-spill 2	54.7 ± 59.7	240.7 ± 245.9	51.4 ± 55.1	14.0 ± 17.2	160.7 ± 129.0	291.3 ± 168.3	304.7 ± 186.6	382.0 ± 174.9
	Post-spill 1	51.3 ± 64.7	235.3 ± 179.7	90.0 ± 90.0	11.1 ± 15.6	192.0 ± 111.7	301.3 ± 168.1	254.0 ± 133.4	340.5 ± 197.5
	Post-spill 2	80.7 ± 96.1	256.0 ± 180.5	86.0 ± 90.9	10.7 ± 18.1	169.3 ± 131.8	377.3 ± 237.8	280.0 ± 210.4	367.3 ± 158.2
	Post-spill 3	60.0 ± 72.2	267.3 ± 185.3	58.7 ± 62.0	8.0 ± 22.6	186.7 ± 209.2	383.3 ± 200.4	254.0 ± 172.0	383.3 ± 180.4
	Post-spill 4	74.7 ± 82.5	298.7 ± 252.0	-	13.3 ± 18.1	152.0 ± 92.5	276.7 ± 129.4	-	344.7 ± 160.3
Astarte montagui	Pre-spill 1	-	144.7 ± 177.3	6.7 ± 23.1	2.0 ± 7.2	-	198.3 ± 151.5	160.7 ± 129.9	448.0 ± 258.8
	Pre-spill 2	16.0 ± 32.3	224.7 ± 239.3	9.0 ± 23.5	1.3 ± 4.5	46.0 ± 45.1	131.3 ± 85.1	165.6 ± 132.7	443.3 ± 208.2
	Post-spill 1	18.0 ± 30.0	281.3 ± 277.0	21.3 ± 42.9	0	46.0 ± 35.1	136.7 ± 85.1	222.7 ± 182.8	496.3 ± 294.5
	Post-spill 2	21.3 ± 33.9	213.3 ± 203.8	12.0 ± 22.3	2.0 ± 5.4	45.3 ± 44.7	164.7 ± 101.8	220.0 ± 176.1	500.7 ± 233.8
	Post-spill 3	16.0 ± 25.8	263.3 ± 249.8	9.3 ± 16.3	0	28.7 ± 41.9	186.0 ± 134.4	186.7 ± 181.4	512.7 ± 224.8
	Post-spill 4	16.0 ± 22.1	388.0 ± 430.9	-	0	38.7 ± 34.3	150.7 ± 96.9	-	507.3 ± 249.0
Astarte juveniles	Pre-spill 1	-	119.3 ± 129.5	207.3 ± 144.7	8.7 ± 21.1	-	132.0 ± 133.4	286.0 ± 238.9	242.7 ± 122.2
	Pre-spill 2	40.0 ± 44.8	145.3 ± 175.8	157.2 ± 93.1	8.7 ± 20.6	35.3 ± 33.4	148.7 ± 106.6	111.3 ± 84.5	224.0 ± 122.4
	Post-spill 1	22.7 ± 23.1	328.7 ± 419.6	120.7 ± 106.2	9.0 ± 20.4	41.3 ± 32.3	124.7 ± 75.3	112.7 ± 109.1	287.0 ± 167.7
	Post-spill 2	28.0 ± 30.7	276.7 ± 370.3	140.7 ± 142.1	4.0 ± 10.8	49.3 ± 45.0	156.7 ± 113.7	86.0 ± 67.2	272.0 ± 215.0
	Post-spill 3	22.0 ± 31.2	126.7 ± 156.1	96.7 ± 71.3	2.7 ± 7.7	72.7 ± 96.7	152.0 ± 104.1	110.7 ± 96.0	248.0 ± 173.6
	Post-spill 4	28.7 ± 38.9	255.3 ± 262.0	-	4.0 ± 13.6	30.7 ± 24.9	94.7 ± 68.2	-	256.7 ± 167.3
Macoma calcarea	Pre-spill 1	-	36.7 ± 42.1	25.3 ± 27.9	6.7 ± 14.1	-	208.7 ± 71.6	114.7 ± 44.2	72.7 ± 35.9
	Pre-spill 2	8.0 ± 14.2	46.7 ± 47.6	14.6 ± 15.9	0	262.0 ± 138.8	196.0 ± 98.0	105.0 ± 48.2	68.0 ± 40.9
	Post-spill 1	14.0 ± 19.6	56.0 ± 62.1	17.3 ± 20.0	1.4 ± 4.6	266.7 ± 120.0	214.7 ± 98.8	110.0 ± 37.8	61.9 ± 37.5
	Post-spill 2	9.3 ± 14.1	44.0 ± 40.9	25.3 ± 21.6	2.0 ± 5.4	257.3 ± 138.1	242.0 ± 84.8	140.0 ± 67.1	80.0 ± 47.2
	Post-spill 3	11.3 ± 13.7	58.3 ± 57.3	14.7 ± 23.4	2.7 ± 7.7	253.3 ± 155.7	212.7 ± 90.5	147.3 ± 73.7	107.3 ± 47.8
	Post-spill 4	12.7 ± 18.9	42.7 ± 46.4	-	2.7 ± 6.1	256.7 ± 111.4	220.7 ± 110.6	-	96.7 ± 55.6
Macoma juveniles	Pre-spill 1	-	41.3 ± 59.1	12.0 ± 15.1	2.7 ± 7.7	-	86.7 ± 60.7	97.3 ± 72.3	86.0 ± 57.6
	Pre-spill 2	3.3 ± 6.1	30.7 ± 37.1	7.0 ± 11.6	0.7 ± 3.3	92.0 ± 60.7	105.3 ± 62.8	60.5 ± 43.4	50.0 ± 43.1
	Post-spill 1	3.3 ± 8.1	26.7 ± 34.7	9.3 ± 20.5	0.7 ± 3.3	147.3 ± 110.3	62.7 ± 45.7	78.3 ± 46.6	37.2 ± 33.7
	Post-spill 2	1.3 ± 4.5	11.3 ± 16.0	2.0 ± 9.8	0.7 ± 3.3	121.3 ± 92.7	98.3 ± 64.0	98.7 ± 68.1	65.3 ± 53.8
	Post-spill 3	0.7 ± 3.3	18.7 ± 25.7	1.3 ± 4.5	0	129.3 ± 101.7	111.3 ± 81.2	89.3 ± 52.3	102.0 ± 67.5
	Post-spill 4	6.7 ± 20.5	50.7 ± 95.0	-	1.3 ± 6.5	111.3 ± 71.6	70.0 ± 55.8	-	78.0 ± 62.9

Continued...

Appendix B. Concluded.

Taxon	Period[2]	3 m Depth				7 m Depth			
		Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Mytilus dianae	Pre-spill 1	-	0	183.3 ± 183.1	81.3 ± 108.2	-	0	0.7 ± 3.3	5.3 ± 18.1
	Pre-spill 2	30.7 ± 25.4	0	93.9 ± 111.2	38.3 ± 67.4	4.7 ± 19.7	0	1.4 ± 4.6	0.7 ± 3.3
	Post-spill 1	12.7 ± 19.4	2.7 ± 6.1	90.7 ± 136.6	82.1 ± 108.3	2.0 ± 7.2	0.7 ± 3.3	2.0 ± 5.4	2.8 ± 7.9
	Post-spill 2	22.7 ± 35.9	2.7 ± 7.7	99.7 ± 120.2	38.0 ± 55.6	0.7 ± 3.3	0.7 ± 3.3	4.0 ± 14.5	6.0 ± 26.2
	Post-spill 3	26.0 ± 47.1	2.7 ± 6.1	96.7 ± 148.8	51.3 ± 124.1	0.7 ± 3.3	0	0.7 ± 3.3	6.0 ± 18.8
	Post-spill 4	36.7 ± 41.8	8.0 ± 14.9	-	37.3 ± 48.3	0	0	-	12.0 ± 31.7
Mytilus niger	Pre-spill 1	-	8.7 ± 17.0	2.0 ± 7.2	2.0 ± 7.2	-	78.7 ± 58.9	26.0 ± 45.5	24.0 ± 24.5
	Pre-spill 2	0	16.7 ± 24.7	0.7 ± 3.3	0.7 ± 3.3	19.3 ± 20.6	58.7 ± 51.4	18.1 ± 29.1	19.3 ± 26.0
	Post-spill 1	0.7 ± 3.3	22.0 ± 33.6	2.0 ± 5.4	0	23.3 ± 29.1	61.3 ± 61.8	22.7 ± 30.9	13.9 ± 23.8
	Post-spill 2	0.7 ± 3.3	18.0 ± 25.5	0	0	31.3 ± 43.1	70.0 ± 62.6	19.3 ± 24.5	18.7 ± 19.8
	Post-spill 3	0	16.0 ± 24.5	0	0	28.7 ± 36.2	74.0 ± 67.2	17.3 ± 22.1	19.3 ± 26.3
	Post-spill 4	0	25.3 ± 40.9	-	0.7 ± 3.3	16.0 ± 18.3	49.3 ± 51.7	-	24.7 ± 30.2
Mytilus juvenile	Pre-spill 1	-	4.0 ± 14.3	160.0 ± 162.0	106.0 ± 129.2	-	106.0 ± 91.6	32.7 ± 50.0	20.7 ± 22.4
	Pre-spill 2	48.7 ± 48.5	14.0 ± 46.8	47.3 ± 53.8	48.7 ± 106.0	67.3 ± 100.7	66.7 ± 72.4	12.5 ± 21.6	12.7 ± 18.9
	Post-spill 1	17.3 ± 24.9	23.3 ± 57.4	46.0 ± 63.0	105.7 ± 132.2	66.0 ± 145.7	49.3 ± 43.0	16.0 ± 30.2	13.6 ± 30.6
	Post-spill 2	32.0 ± 39.2	6.7 ± 10.5	84.0 ± 109.9	78.3 ± 134.7	152.0 ± 275.7	118.7 ± 91.1	20.7 ± 19.7	22.7 ± 24.9
	Post-spill 3	33.3 ± 39.2	6.7 ± 13.3	113.3 ± 141.9	66.0 ± 171.2	136.7 ± 215.6	122.0 ± 108.7	45.3 ± 41.8	32.0 ± 36.5
	Post-spill 4	103.3 ± 124.8	29.3 ± 51.2	-	75.3 ± 83.5	75.3 ± 76.6	101.3 ± 84.4	-	48.3 ± 53.6
Nucula minuta	Pre-spill 1	-	0.7 ± 3.3	3.3 ± 9.4	0	-	122.0 ± 71.5	80.0 ± 50.2	84.7 ± 38.5
	Pre-spill 2	3.3 ± 8.1	0.7 ± 3.3	2.8 ± 7.9	0	76.7 ± 46.0	156.7 ± 68.5	58.4 ± 32.9	87.3 ± 42.7
	Post-spill 1	0.7 ± 3.3	0	3.3 ± 6.6	2.8 ± 7.9	92.7 ± 65.5	135.3 ± 56.4	56.7 ± 38.9	104.3 ± 45.7
	Post-spill 2	0	2.0 ± 5.4	2.0 ± 5.4	0	101.3 ± 102.4	169.3 ± 72.2	71.3 ± 60.2	130.0 ± 76.0
	Post-spill 3	0	0.7 ± 3.3	0.7 ± 3.3	0	90.7 ± 60.4	159.3 ± 81.2	77.3 ± 39.9	135.3 ± 79.9
	Post-spill 4	0.7 ± 3.3	0.7 ± 3.3	-	0	62.0 ± 37.2	136.0 ± 59.3	-	113.3 ± 64.5
Serripes groenlandicus	Pre-spill 1	-	24.7 ± 48.6	1.3 ± 4.5	0.7 ± 3.3	-	84.0 ± 57.8	33.3 ± 35.9	13.3 ± 23.9
	Pre-spill 2	0	29.3 ± 52.5	0	2.7 ± 10.2	44.7 ± 31.6	58.7 ± 45.9	24.4 ± 25.8	17.3 ± 23.6
	Post-spill 1	0	16.7 ± 22.4	0.7 ± 3.3	0	39.3 ± 38.3	46.7 ± 35.0	20.7 ± 19.2	13.2 ± 25.4
	Post-spill 2	8.0 ± 29.5	20.0 ± 20.2	0.7 ± 3.3	4.0 ± 10.8	56.7 ± 52.1	62.0 ± 50.2	26.7 ± 29.7	8.7 ± 14.1
	Post-spill 3	5.3 ± 13.9	28.0 ± 39.0	0.7 ± 3.3	0.7 ± 3.3	51.3 ± 41.7	57.3 ± 38.3	24.7 ± 23.1	10.7 ± 14.7
	Post-spill 4	2.7 ± 7.7	22.0 ± 27.8	-	0.7 ± 3.3	34.0 ± 34.3	48.0 ± 36.2	-	8.7 ± 15.6
Gastropods	Pre-spill 1	-	399.3 ± 221.5	358.0 ± 200.6	174.0 ± 145.1	-	234.0 ± 159.8	163.3 ± 77.8	304.7 ± 157.2
	Pre-spill 2	468.0 ± 278.0	498.0 ± 253.4	253.9 ± 157.8	93.8 ± 104.0	334.7 ± 158.1	252.0 ± 108.3	168.3 ± 77.0	318.7 ± 194.1
	Post-spill 1	327.3 ± 312.5	762.0 ± 587.2	308.0 ± 202.8	97.6 ± 106.0	334.0 ± 111.2	196.7 ± 77.7	155.3 ± 109.3	367.7 ± 212.3
	Post-spill 2	655.5 ± 303.9	863.3 ± 446.2	369.6 ± 265.6	102.7 ± 109.5	384.0 ± 268.9	321.3 ± 173.2	272.3 ± 205.3	478.4 ± 236.1
	Post-spill 3	628.0 ± 310.0	763.3 ± 413.3	407.1 ± 262.8	77.0 ± 100.6	381.3 ± 228.6	257.3 ± 167.7	225.3 ± 127.2	468.7 ± 164.3
	Post-spill 4	738.1 ± 313.9	884.7 ± 355.9	-	102.5 ± 86.9	376.7 ± 178.2	246.0 ± 120.2	-	423.0 ± 232.9
Cingula castanea	Pre-spill 1	-	182.7 ± 150.1	143.3 ± 101.2	15.3 ± 22.4	-	86.0 ± 100.1	38.7 ± 39.7	26.7 ± 33.9
	Pre-spill 2	303.3 ± 226.1	224.7 ± 149.2	83.5 ± 72.8	5.5 ± 11.9	116.0 ± 108.0	100.0 ± 78.5	37.6 ± 40.2	26.0 ± 47.4
	Post-spill 1	299.3 ± 362.0	442.0 ± 478.5	117.3 ± 94.9	3.5 ± 16.7	98.7 ± 56.9	52.7 ± 38.5	25.0 ± 31.9	40.3 ± 42.8
	Post-spill 2	380.8 ± 221.8	490.7 ± 352.1	184.9 ± 173.4	8.0 ± 15.6	131.3 ± 151.9	134.7 ± 129.8	48.0 ± 80.9	56.5 ± 63.8
	Post-spill 3	413.3 ± 270.3	424.0 ± 352.2	181.3 ± 146.9	6.7 ± 14.9	133.3 ± 80.9	78.7 ± 85.4	50.6 ± 40.4	68.0 ± 61.2
	Post-spill 4	452.7 ± 278.1	554.0 ± 287.8	-	16.7 ± 31.8	120.7 ± 78.0	74.0 ± 69.6	-	38.0 ± 35.2
Retusa obtusa	Pre-spill 1	-	106.0 ± 60.8	40.7 ± 46.9	33.3 ± 40.3	-	46.7 ± 52.5	14.0 ± 25.1	23.3 ± 26.3
	Pre-spill 2	28.7 ± 32.0	100.0 ± 70.5	32.0 ± 34.5	16.8 ± 24.1	28.7 ± 34.7	38.7 ± 35.0	37.6 ± 23.9	33.3 ± 36.5
	Post-spill 1	46.0 ± 39.8	126.7 ± 65.9	38.0 ± 36.5	11.1 ± 21.8	38.0 ± 31.2	32.7 ± 32.9	32.7 ± 41.3	51.1 ± 47.8
	Post-spill 2	52.7 ± 37.9	142.0 ± 71.0	54.7 ± 52.1	31.3 ± 51.4	33.3 ± 31.3	58.0 ± 43.2	48.7 ± 52.4	60.7 ± 58.9
	Post-spill 3	44.7 ± 55.8	144.7 ± 119.1	65.3 ± 72.9	8.0 ± 17.0	54.7 ± 62.9	42.0 ± 40.3	32.0 ± 36.2	70.0 ± 44.5
	Post-spill 4	98.0 ± 86.5	161.3 ± 85.2	-	33.3 ± 37.4	34.7 ± 24.4	44.7 ± 40.9	-	60.0 ± 35.4
Trichotropis borealis	Pre-spill 1	-	36.7 ± 41.0	4.0 ± 19.6	12.7 ± 42.1	-	29.3 ± 24.8	49.3 ± 42.2	117.3 ± 81.1
	Pre-spill 2	12.7 ± 18.3	67.3 ± 66.9	7.0 ± 13.5	0	63.3 ± 41.3	38.7 ± 32.0	36.2 ± 31.0	78.7 ± 60.8
	Post-spill 1	42.7 ± 50.7	71.3 ± 63.3	24.0 ± 56.4	0	53.3 ± 44.7	41.3 ± 33.7	37.3 ± 36.7	86.6 ± 74.8
	Post-spill 2	16.0 ± 21.6	61.3 ± 60.0	22.0 ± 43.2	0	62.0 ± 43.1	38.7 ± 40.0	56.0 ± 53.6	125.3 ± 88.6
	Post-spill 3	20.0 ± 35.4	64.7 ± 56.9	28.7 ± 56.4	0	61.3 ± 59.8	38.7 ± 36.5	45.3 ± 37.1	113.3 ± 81.3
	Post-spill 4	35.3 ± 35.6	67.3 ± 54.8	-	0	49.3 ± 54.2	37.3 ± 30.1	-	100.0 ± 85.9
Musleria costulata	Pre-spill 1	-	2.0 ± 5.4	0.7 ± 3.3	0	-	16.7 ± 21.4	14.7 ± 17.6	45.3 ± 48.5
	Pre-spill 2	10.7 ± 27.4	10.7 ± 22.0	0.7 ± 3.3	0	33.3 ± 25.8	24.0 ± 27.1	10.4 ± 21.9	50.0 ± 52.2
	Post-spill 1	12.0 ± 25.5	12.0 ± 15.8	1.3 ± 6.5	0	47.3 ± 34.8	18.7 ± 18.1	6.0 ± 10.4	51.5 ± 56.5
	Post-spill 2	13.3 ± 18.1	4.7 ± 12.0	4.0 ± 9.7	0	44.0 ± 41.7	32.7 ± 25.6	25.3 ± 24.9	62.7 ± 71.1
	Post-spill 3	19.3 ± 35.6	6.7 ± 12.4	8.7 ± 23.1	0	44.7 ± 29.1	34.7 ± 35.2	17.3 ± 16.3	78.0 ± 52.2
	Post-spill 4	16.0 ± 32.7	2.7 ± 6.1	-	0	50.7 ± 36.1	24.7 ± 23.6	-	43.3 ± 37.3
Myriotrochus rinkii	Pre-spill 1	-	351.3 ± 174.7	146.0 ± 141.6	93.3 ± 80.3	-	86.0 ± 105.6	0.7 ± 3.3	26.7 ± 67.3
	Pre-spill 2	106.7 ± 106.1	279.3 ± 160.9	81.3 ± 59.6	96.0 ± 83.2	26.0 ± 57.4	32.0 ± 44.0	10.4 ± 26.7	5.3 ± 12.2
	Post-spill 1	118.7 ± 103.4	278.7 ± 133.7	135.3 ± 114.1	144.6 ± 171.8	6.7 ± 17.0	64.0 ± 84.4	2.7 ± 6.1	11.8 ± 31.0
	Post-spill 2	248.2 ± 152.1	355.3 ± 271.2	146.2 ± 177.4	109.7 ± 91.0	17.3 ± 41.9	82.7 ± 92.3	1.3 ± 4.5	11.7 ± 38.2
	Post-spill 3	182.0 ± 147.2	268.7 ± 107.3	156.7 ± 230.2	105.0 ± 108.1	12.7 ± 29.5	66.0 ± 94.8	0.7 ± 3.3	9.3 ± 18.8
	Post-spill 4	344.8 ± 216.8	331.3 ± 165.2	-	223.0 ± 146.7	4.0 ± 8.5	44.0 ± 63.2	-	6.0 ± 10.4

Appendix E. Mean biomass (g/m^2) of major taxa and dominant species of infauna in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Data are expressed as mean ± standard deviation and are based on 10% formalin wet weight in 8 replicate 0.0025 m^2 airlift samples on each of three transects for each depth, period and bay.

Taxon	Period[2]	3 m Depth				7 m Depth			
		Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Total infauna[3]	Pre-spill 1	-	580.6 ± 407.6	328.0 ± 234.7	80.1 ± 110.1	-	2267.3 ± 1048.6	1530.5 ± 578.7	1232.3 ± 638.6
	Pre-spill 2	169.1 ± 176.4	675.2 ± 484.1	334.5 ± 272.6	58.5 ± 61.8	982.8 ± 707.4	1411.2 ± 899.1	1213.2 ± 669.6	1335.8 ± 784.1
	Post-spill 1	237.5 ± 208.1	887.2 ± 704.9	474.6 ± 385.6	82.0 ± 93.4	1238.3 ± 638.6	1308.2 ± 583.9	1187.1 ± 596.6	1233.7 ± 761.8
	Post-spill 2	253.4 ± 254.4	871.6 ± 568.3	460.6 ± 451.1	88.7 ± 97.8	1137.6 ± 878.0	1716.3 ± 862.7	1226.6 ± 837.6	1263.1 ± 518.0
	Post-spill 3	214.7 ± 207.4	918.0 ± 597.4	426.6 ± 327.2	76.1 ± 83.1	1073.5 ± 686.7	1877.3 ± 966.4	1239.8 ± 756.5	1458.8 ± 864.7
	Post-spill 4	350.0 ± 392.9	1073.9 ± 889.1	-	81.4 ± 56.0	1240.8 ± 553.0	2166.1 ± 961.5	-	1634.3 ± 886.8
Bivalvia	Pre-spill 1	-	329.5 ± 400.7	264.3 ± 220.6	54.3 ± 88.5	-	2196.8 ± 1053.3	1439.8 ± 581.7	1128.9 ± 624.7
	Pre-spill 2	138.4 ± 162.1	609.2 ± 468.7	300.9 ± 261.3	35.2 ± 58.0	868.9 ± 695.8	1332.7 ± 835.4	1122.1 ± 684.3	1261.4 ± 776.2
	Post-spill 1	200.4 ± 196.0	827.1 ± 689.5	420.9 ± 378.2	49.4 ± 85.1	1171.4 ± 641.7	1240.4 ± 586.6	1115.7 ± 592.7	1172.9 ± 763.2
	Post-spill 2	215.0 ± 238.4	802.6 ± 553.5	417.6 ± 431.9	66.5 ± 96.2	1078.6 ± 881.4	1640.6 ± 848.4	1147.1 ± 837.2	1180.3 ± 523.6
	Post-spill 3	173.8 ± 189.8	807.5 ± 596.4	370.2 ± 314.0	45.3 ± 73.2	993.5 ± 661.5	1796.0 ± 959.9	1158.9 ± 764.0	1382.7 ± 813.6
	Post-spill 4	296.6 ± 389.4	986.0 ± 873.8	-	42.5 ± 49.0	1180.2 ± 537.9	2067.6 ± 945.2	-	1553.8 ± 866.5
Nya truncata	Pre-spill 1	-	235.6 ± 172.5	134.7 ± 167.3	17.3 ± 48.3	-	1120.8 ± 753.6	661.4 ± 476.6	513.8 ± 446.7
	Pre-spill 2	60.6 ± 103.5	248.5 ± 215.4	190.2 ± 177.5	21.2 ± 48.8	481.5 ± 496.8	561.7 ± 479.8	544.7 ± 407.1	567.5 ± 560.8
	Post-spill 1	103.3 ± 114.1	410.9 ± 333.2	175.6 ± 188.8	27.0 ± 64.2	728.5 ± 486.4	565.7 ± 372.5	544.6 ± 458.0	556.0 ± 506.9
	Post-spill 2	115.0 ± 147.8	411.6 ± 397.7	221.7 ± 295.1	13.6 ± 30.8	592.1 ± 702.7	619.5 ± 384.8	462.6 ± 475.2	476.7 ± 361.1
	Post-spill 3	85.7 ± 118.0	386.2 ± 314.3	246.5 ± 269.5	9.8 ± 25.5	588.3 ± 593.1	861.0 ± 728.9	570.4 ± 387.8	624.1 ± 537.5
	Post-spill 4	151.4 ± 225.5	499.0 ± 486.6	-	5.3 ± 13.6	727.0 ± 437.2	1074.3 ± 702.0	-	773.1 ± 665.2
Astarte borealis	Pre-spill 1	-	171.7 ± 182.7	32.3 ± 67.2	11.0 ± 27.4	-	316.9 ± 291.8	355.0 ± 308.5	330.3 ± 263.0
	Pre-spill 2	40.1 ± 49.3	210.4 ± 236.3	46.8 ± 93.6	3.6 ± 6.5	45.3 ± 47.4	221.0 ± 164.2	222.4 ± 214.5	389.2 ± 212.5
	Post-spill 1	51.8 ± 87.5	235.8 ± 255.9	155.4 ± 211.1	4.0 ± 10.6	83.8 ± 76.2	190.3 ± 141.4	284.2 ± 243.2	284.1 ± 230.8
	Post-spill 2	58.5 ± 108.8	195.5 ± 210.8	95.6 ± 179.8	6.7 ± 23.2	75.0 ± 70.9	309.3 ± 213.6	264.8 ± 274.2	398.6 ± 264.8
	Post-spill 3	51.9 ± 62.9	243.3 ± 260.4	58.7 ± 119.3	10.5 ± 30.4	81.6 ± 68.8	287.3 ± 198.7	249.5 ± 330.4	374.1 ± 292.8
	Post-spill 4	77.2 ± 127.4	273.0 ± 334.1	-	10.1 ± 22.2	72.4 ± 81.6	236.6 ± 156.4	-	386.9 ± 335.5
Astarte montagui	Pre-spill 1	-	51.2 ± 65.9	3.6 ± 11.6	0.7 ± 3.6	-	61.3 ± 58.0	51.5 ± 67.1	146.6 ± 96.3
	Pre-spill 2	3.5 ± 8.2	77.3 ± 81.7	3.3 ± 7.2	1.3 ± 4.3	9.7 ± 11.1	36.9 ± 22.0	59.6 ± 65.0	158.6 ± 93.8
	Post-spill 1	3.2 ± 6.8	99.0 ± 90.2	8.6 ± 18.4	0	12.3 ± 13.6	48.0 ± 46.1	61.9 ± 57.3	166.4 ± 97.6
	Post-spill 2	6.5 ± 13.7	69.2 ± 75.6	5.7 ± 13.4	0.9 ± 2.9	11.9 ± 13.1	45.9 ± 31.9	71.4 ± 52.1	161.7 ± 74.5
	Post-spill 3	6.9 ± 13.5	98.7 ± 107.3	2.5 ± 5.1	0	7.4 ± 9.3	53.9 ± 42.5	52.5 ± 52.0	179.7 ± 99.0
	Post-spill 4	4.7 ± 7.9	108.7 ± 149.5	-	0	14.6 ± 17.5	37.8 ± 25.4	-	186.6 ± 101.0
Serripes groenlandicus	Pre-spill 1	-	13.6 ± 26.3	1.2 ± 5.7	2.2 ± 10.8	-	360.6 ± 367.3	186.6 ± 206.8	28.4 ± 61.1
	Pre-spill 2	0	26.8 ± 48.2	0	0.1 ± 0.6	132.9 ± 145.6	290.7 ± 286.0	156.3 ± 182.1	57.8 ± 113.5
	Post-spill 1	0	21.8 ± 57.7	0.2 ± 0.9	0	111.8 ± 149.8	199.8 ± 175.8	80.5 ± 116.8	52.5 ± 134.5
	Post-spill 2	0.2 ± 0.7	43.3 ± 78.8	<0.1	28.6 ± 89.2	207.8 ± 280.2	385.4 ± 314.1	167.2 ± 211.0	33.4 ± 63.8
	Post-spill 3	0.5 ± 1.0	40.0 ± 70.0	<0.1	1.3 ± 6.4	122.9 ± 160.9	345.6 ± 259.6	118.2 ± 174.2	45.6 ± 103.7
	Post-spill 4	0.1 ± 0.4	34.7 ± 66.5	-	6.1 ± 30.1	156.2 ± 221.6	402.1 ± 319.8	-	58.0 ± 132.9
Mistalia arctica	Pre-spill 1	-	37.3 ± 53.9	28.1 ± 61.6	3.4 ± 12.3	-	126.7 ± 196.2	7.9 ± 19.7	7.6 ± 26.9
	Pre-spill 2	16.9 ± 35.0	18.0 ± 30.1	17.8 ± 47.0	<0.1	5.3 ± 15.6	20.6 ± 39.6	3.0 ± 7.8	20.1 ± 45.8
	Post-spill 1	28.1 ± 51.1	26.9 ± 43.3	32.1 ± 73.8	1.1 ± 3.3	3.3 ± 15.9	24.2 ± 45.9	3.3 ± 15.4	11.0 ± 30.6
	Post-spill 2	18.9 ± 32.8	56.8 ± 69.3	34.9 ± 53.5	4.8 ± 15.6	<0.1	44.2 ± 101.5	1.7 ± 8.2	12.5 ± 31.2
	Post-spill 3	11.9 ± 23.4	38.1 ± 50.7	11.9 ± 26.9	4.1 ± 12.1	6.4 ± 21.9	31.7 ± 86.5	15.5 ± 41.5	48.6 ± 97.7
	Post-spill 4	29.7 ± 70.6	36.3 ± 59.3	-	0.9 ± 3.0	0.1 ± 0.3	52.5 ± 119.0	-	16.0 ± 38.6
Macoma calcarea	Pre-spill 1	-	10.5 ± 16.6	5.1 ± 6.7	3.1 ± 7.5	-	83.9 ± 48.7	72.8 ± 44.1	53.8 ± 44.8
	Pre-spill 2	4.0 ± 8.6	16.4 ± 20.3	7.0 ± 15.5	0	111.4 ± 74.4	78.5 ± 47.4	74.2 ± 61.8	36.5 ± 39.8
	Post-spill 1	7.2 ± 11.6	14.1 ± 21.9	4.3 ± 8.5	2.5 ± 8.3	117.6 ± 63.6	78.4 ± 42.0	65.0 ± 38.9	41.3 ± 28.8
	Post-spill 2	4.3 ± 8.0	12.3 ± 15.3	15.5 ± 18.2	0.4 ± 1.4	130.2 ± 74.1	108.4 ± 49.3	101.1 ± 65.7	51.9 ± 45.3
	Post-spill 3	5.5 ± 9.9	18.7 ± 21.6	7.0 ± 14.2	2.2 ± 6.5	130.4 ± 86.4	98.4 ± 42.8	80.6 ± 46.5	61.2 ± 47.9
	Post-spill 4	11.0 ± 17.3	11.5 ± 13.9	-	2.5 ± 7.4	140.0 ± 67.2	111.2 ± 47.2	-	60.0 ± 47.1

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).
3 All taxa but nematodes and ophiuroids crustaceans and echinoderms.

Continued...

Appendix E. Concluded.

Taxon	Period[2]	5 m Depth				7 m Depth			
		Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Musculus discors	Pre-spill 1	-	0	55.1 ± 63.7	15.1 ± 26.9	-	0	0.1 ± 0.4	2.6 ± 8.9
	Pre-spill 2	11.6 ± 14.0	0	31.9 ± 36.4	7.5 ± 16.4	1.8 ± 9.0	0	2.3 ± 8.2	<0.1
	Post-spill 1	3.7 ± 6.0	0.9 ± 2.8	38.6 ± 67.2	14.2 ± 19.5	0.2 ± 0.6	<0.1	1.2 ± 4.6	1.3 ± 4.4
	Post-spill 2	9.3 ± 12.7	1.7 ± 6.0	41.3 ± 46.8	10.8 ± 19.7	<0.1	<0.1	6.4 ± 31.1	1.3 ± 5.0
	Post-spill 3	9.8 ± 26.1	1.1 ± 4.3	40.5 ± 62.3	17.3 ± 48.9	<0.1	0	0.9 ± 4.6	1.2 ± 3.9
	Post-spill 4	15.9 ± 22.6	1.9 ± 4.7	-	15.6 ± 18.6	0	0	-	3.4 ± 7.9
Musculus niger	Pre-spill 1	-	1.3 ± 2.5	0.1 ± 0.3	0.2 ± 0.7	-	31.7 ± 41.9	12.1 ± 21.8	14.5 ± 23.5
	Pre-spill 2	0	2.6 ± 4.0	<0.1	<0.1	3.8 ± 6.6	27.4 ± 48.7	12.9 ± 23.7	3.7 ± 4.5
	Post-spill 1	0.1 ± 0.3	4.0 ± 7.4	0.4 ± 1.3	0	15.4 ± 27.7	23.4 ± 33.5	22.3 ± 34.1	5.4 ± 9.8
	Post-spill 2	<0.1	3.1 ± 4.8	0	0	12.2 ± 22.1	26.2 ± 26.9	19.2 ± 31.8	13.4 ± 25.5
	Post-spill 3	0	4.0 ± 7.3	0	0	9.9 ± 20.2	25.8 ± 27.3	12.2 ± 21.1	16.6 ± 28.6
	Post-spill 4	0	3.5 ± 12.4	-	<0.1	5.5 ± 10.1	23.2 ± 34.4	-	18.7 ± 28.3
Clinocardium ciliatum	Pre-spill 1	-	0	0	0	-	27.4 ± 106.3	50.5 ± 171.7	0
	Pre-spill 2	0	0	0	0	23.2 ± 77.7	52.6 ± 184.5	30.1 ± 96.2	22.5 ± 76.9
	Post-spill 1	0	0	0	0	35.0 ± 105.3	63.9 ± 134.7	19.2 ± 96.1	34.9 ± 119.6
	Post-spill 2	0	0	0	0	0.7 ± 3.3	18.1 ± 45.0	28.6 ± 97.3	0
	Post-spill 3	0	0	0	0	0	41.4 ± 107.0	25.2 ± 72.1	0
	Post-spill 4	0	0	-	0	0	40.2 ± 108.7	-	0
Macoma inquinata	Pre-spill 1	-	<0.1	<0.1	0	-	21.3 ± 12.1	5.8 ± 5.6	7.7 ± 6.1
	Pre-spill 2	0.2 ± 0.7	0.1 ± 0.7	<0.1	0	13.8 ± 10.8	22.7 ± 10.6	5.1 ± 4.9	7.1 ± 4.2
	Post-spill 1	<0.1	0	0.1 ± 0.2	0.2 ± 0.6	16.2 ± 13.8	20.6 ± 12.3	4.3 ± 4.8	9.3 ± 5.6
	Post-spill 2	0	<0.1	0.2 ± 0.5	0	13.3 ± 10.7	28.6 ± 14.9	5.1 ± 5.4	9.0 ± 6.0
	Post-spill 3	0	<0.1	<0.1	0	15.1 ± 13.1	23.1 ± 12.1	6.0 ± 6.2	9.9 ± 7.8
	Post-spill 4	0.3 ± 1.5	<0.1	-	0	9.5 ± 6.3	26.0 ± 12.4	-	8.2 ± 6.2
Polychaeta	Pre-spill 1	-	40.0 ± 13.8	34.0 ± 22.6	18.6 ± 14.0	-	53.1 ± 33.9	43.9 ± 42.5	36.1 ± 28.7
	Pre-spill 2	15.5 ± 12.6	43.1 ± 21.4	24.7 ± 14.2	13.8 ± 7.5	33.1 ± 26.9	43.6 ± 28.7	37.5 ± 19.5	45.1 ± 24.9
	Post-spill 1	16.8 ± 9.2	41.7 ± 20.1	36.9 ± 21.4	21.9 ± 17.9	31.0 ± 20.2	34.3 ± 16.0	46.0 ± 29.4	36.0 ± 23.4
	Post-spill 2	18.2 ± 14.3	42.1 ± 36.1	28.6 ± 21.1	18.1 ± 9.8	30.8 ± 18.0	36.4 ± 23.4	42.5 ± 24.7	38.8 ± 19.7
	Post-spill 3	18.2 ± 12.4	53.2 ± 25.3	22.3 ± 10.8	14.4 ± 10.9	36.8 ± 16.8	39.7 ± 23.1	50.1 ± 30.4	45.8 ± 22.8
	Post-spill 4	28.5 ± 15.5	48.7 ± 21.9	-	24.6 ± 18.1	29.5 ± 22.2	44.4 ± 25.5	-	38.9 ± 30.1
Pectinaria granulata	Pre-spill 1	-	9.5 ± 8.4	7.7 ± 9.9	7.3 ± 11.1	-	10.1 ± 9.5	25.8 ± 12.0	17.2 ± 12.1
	Pre-spill 2	5.5 ± 7.4	10.8 ± 8.9	6.1 ± 11.3	3.1 ± 3.8	13.5 ± 14.5	20.5 ± 12.4	18.6 ± 15.3	13.7 ± 10.7
	Post-spill 1	4.7 ± 5.7	6.1 ± 7.0	7.4 ± 8.8	2.2 ± 5.5	13.5 ± 11.4	11.8 ± 7.4	17.7 ± 20.5	14.0 ± 11.9
	Post-spill 2	6.1 ± 10.1	7.4 ± 8.1	9.1 ± 14.8	3.5 ± 4.1	12.7 ± 14.0	9.7 ± 8.3	19.8 ± 15.3	11.9 ± 7.9
	Post-spill 3	3.3 ± 5.3	8.0 ± 11.1	5.3 ± 7.2	2.3 ± 5.9	13.2 ± 10.9	13.2 ± 9.6	18.5 ± 14.5	13.7 ± 8.7
	Post-spill 4	5.6 ± 8.4	8.1 ± 9.3	-	3.9 ± 6.4	12.5 ± 14.7	11.3 ± 8.0	-	9.8 ± 5.0
Gastropoda	Pre-spill 1	-	9.3 ± 8.5	4.0 ± 5.3	3.6 ± 11.9	-	9.9 ± 8.4	11.9 ± 13.3	44.1 ± 44.1
	Pre-spill 2	5.1 ± 5.4	14.4 ± 12.6	5.8 ± 5.0	0.5 ± 0.6	10.1 ± 7.8	15.8 ± 22.8	20.2 ± 25.0	16.4 ± 13.3
	Post-spill 1	12.6 ± 10.5	17.0 ± 13.5	8.0 ± 10.9	0.7 ± 1.7	10.9 ± 7.9	15.2 ± 26.1	11.3 ± 17.5	24.9 ± 29.4
	Post-spill 2	8.8 ± 8.8	14.3 ± 13.0	7.3 ± 9.1	0.4 ± 0.4	11.0 ± 7.9	14.1 ± 15.0	29.8 ± 44.3	30.8 ± 28.3
	Post-spill 3	8.6 ± 7.1	15.1 ± 9.3	8.3 ± 12.7	0.6 ± 0.6	12.0 ± 11.8	15.0 ± 25.2	9.3 ± 7.6	23.9 ± 18.0
	Post-spill 4	8.7 ± 7.7	14.6 ± 8.5	-	0.8 ± 0.8	11.0 ± 10.7	14.6 ± 17.2	-	24.5 ± 23.0
Trichotropis borealis	Pre-spill 1	-	7.2 ± 7.8	1.1 ± 3.3	3.3 ± 11.3	-	5.3 ± 3.1	3.5 ± 3.7	21.3 ± 18.3
	Pre-spill 2	1.9 ± 3.1	12.3 ± 11.8	1.5 ± 3.3	0	6.6 ± 5.1	5.6 ± 5.4	5.3 ± 5.5	11.9 ± 9.9
	Post-spill 1	7.2 ± 9.6	13.4 ± 12.1	4.0 ± 9.6	0	6.4 ± 7.0	4.3 ± 5.6	4.7 ± 5.1	14.2 ± 13.1
	Post-spill 2	2.3 ± 3.6	10.9 ± 10.5	4.1 ± 7.7	0	6.6 ± 5.9	5.1 ± 5.3	10.7 ± 10.2	20.1 ± 17.4
	Post-spill 3	3.3 ± 6.1	11.0 ± 9.6	3.7 ± 6.8	0	5.4 ± 5.8	5.8 ± 7.3	6.5 ± 6.3	17.3 ± 13.6
	Post-spill 4	4.4 ± 4.7	10.6 ± 8.3	-	0	5.0 ± 6.6	6.4 ± 6.7	-	15.7 ± 14.8
Holothuroidea									
Myriotrochus rinkii	Pre-spill 1	-	6.3 ± 4.5	4.9 ± 4.8	5.1 ± 6.7	-	4.9 ± 5.1	0.1 ± 0.3	1.4 ± 3.2
	Pre-spill 2	4.2 ± 3.6	6.8 ± 3.5	5.4 ± 4.4	8.6 ± 9.2	1.7 ± 3.0	2.2 ± 2.8	0.5 ± 2.0	0.2 ± 0.7
	Post-spill 1	4.5 ± 3.6	8.7 ± 5.9	9.3 ± 7.1	7.8 ± 7.5	0.3 ± 1.4	4.8 ± 8.2	0.2 ± 0.7	0.7 ± 2.1
	Post-spill 2	5.7 ± 3.2	7.2 ± 7.0	4.1 ± 3.7	3.6 ± 2.6	1.5 ± 3.4	4.5 ± 4.9	0.1 ± 0.2	2.0 ± 8.9
	Post-spill 3	3.8 ± 2.8	5.6 ± 4.1	2.9 ± 3.5	5.2 ± 6.1	0.8 ± 1.9	4.1 ± 5.6	<0.1	0.2 ± 0.6
	Post-spill 4	7.5 ± 3.6	10.1 ± 4.8	-	11.7 ± 9.6	0.4 ± 1.3	2.2 ± 2.5	-	0.2 ± 0.6

Appendix F. Three-factor analyses of variance for the biomasses and densities of major taxa and dominant species of infauna at a depth in three bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

		Source of Variation and df[3]				
		Period 4,6 or 30	Bay 2,6 or 30	Period x Bay[4] 8,6 or 30	Transect (Bay) 6,313	Per x Trans (Bay) 24,313
Biomass	Total infauna	0.49 ns	58.57 ***	0.12 ns	16.67 ***	0.92 ns
	Polychaeta	0.65 ns	35.91 ***	0.82 ns	6.87 ***	1.33 ns
	Bivalvia	0.45 ns	61.29 ***	0.14 ns	15.10 ***	1.03 ns
	Mya truncata	0.23 ns	53.52 ***	0.18 ns	12.44 ***	1.26 ns
	Astarte borealis	0.26 ns	19.18 ***	0.20 ns	32.11 ***	0.93 ns
	Astarte montagui	0.04 ns	4.90 ns	0.03 ns	66.30 ***	1.89 **
	Macoma calcarea	0.22 ns	9.16 ***	0.50 ns	20.58 ***	0.76 ns
Density	Total infauna	1.54 ns	82.31 ***	0.28 ns	8.26 ***	1.28 ns
	Polychaeta	1.67 ns	31.30 ***	0.30 ns	3.55 **	1.57 *
	Pholoe minuta	0.12 ns	18.13 **	0.11 ns	6.31 ***	1.79 *
	Nereimyra punctata	0.31 ns	5.16 *	0.48 ns	26.17 ***	1.47 ns
	Euchone analis	0.74 ns	54.30 ***	0.57 ns	13.06 ***	1.51 ns
	Spio spp.	28.45 ***	1.87 ns	0.77 ns	6.49 ***	2.20 **
	Eteone longa	0.32 ns	5.86 **	0.94 ns	8.04 ***	1.12 ns
	Chaetozone setosa	1.89 ns	17.18 ***	0.24 ns	7.94 ***	0.87 ns
	Capitella capitata	0.59 ns	3.70 *	0.22 ns	15.53 ***	1.20 ns
	Bivalvia	1.30 ns	62.92 ***	0.62 ns	15.99 ***	0.82 ns
	Mya truncata	4.03 **	137.36 ***	0.64 ns	4.63 ***	0.78 ns
	Thyasiridae spp.	0.20 ns	51.96 ***	0.19 ns	20.83 ***	1.55 ns
	Astarte borealis	0.30 ns	31.76 ***	0.34 ns	28.00 ***	0.74 ns
	Astarte montagui	0.04 ns	6.86 *	0.03 ns	64.52 ***	1.68 *
	Astarte juveniles	0.17 ns	17.80 **	0.28 ns	13.29 ***	1.72 *
	Musculus discors	0.50 ns	22.66 ***	0.39 ns	19.00 ***	0.95 ns
	Musculus juveniles	0.78 ns	24.30 ***	1.20 ns	8.79 ***	0.72 ns
	Gastropoda	0.67 ns	87.42 ***	1.63 ns	7.18 ***	1.11 ns
	Cingula castanea	1.38 ns	137.11 ***	1.15 ns	11.20 ***	0.75 ns
	Retusa obtusa	1.10 ns	72.79 ***	0.83 ns	3.52 **	1.38 ns
	Holothuroidea					
	Myriotrochus rinkii	0.32 ns	18.61 **	0.10 ns	3.87 ***	1.75 *

[1] Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.

[4] The Period x Bay term is the test of oil effects.

Appendix G. Three-factor analyses of variance for the biomasses and densities of major taxa and dominant species of infauna at 3 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982[2]. Transects are nested within bays. P-values are shown with significance levels (ns = $P>0.05$; * $P\leq0.05$; ** $P\leq0.01$; *** $P\leq0.001$).

		Source of Variation and df[3]				
		Period 3,8 or 32	Bay 3,8 or 32	Period x Bay[4] 9,8 or 32	Trans (Bay) 8,334	Per x Trans (Bay) 24,334
Biomass	Total infauna	0.61 ns	33.69 ***	0.06 ns	11.94 ***	0.96 ns
	Polychaeta	0.40 ns	14.19 **	0.36 ns	4.71 ***	1.66 *
	Bivalvia	0.51 ns	35.41 ***	0.06 ns	11.12 ***	0.89 ns
	Mya truncata	0.30 ns	31.17 ***	0.16 ns	9.02 ***	1.20 ns
	Astarte borealis	0.17 ns	12.85 ***	0.18 ns	20.63 ***	0.88 ns
	Astarte montagui	0.01 ns	4.94 *	0.02 ns	47.11 ***	2.06 **
	Macoma calcarea	0.17 ns	7.47 ***	0.50 ns	13.03 ***	0.63 ns
Density	Total infauna	4.59 **	44.38 ***	0.49 ns	6.46 ***	1.54 ns
	Polychaeta	7.79 **	22.31 ***	0.96 ns	2.62 **	1.91 **
	Pholoe minuta	0.78 ns	25.66 ***	0.14 ns	5.65 ***	1.45 ns
	Nereimyra punctata	0.98 ns	2.97 *	0.79 ns	16.01 ***	1.11 ns
	Buchone analis	0.69 ns	14.69 **	0.16 ns	7.83 ***	1.57 *
	Spio spp.	7.11 *	53.91 ***	1.47 ns	5.06 ***	2.60 ***
	Etcone longa	0.94 ns	8.84 ***	0.92 ns	3.84 ***	1.03 ns
	Chaetozone setosa	3.19 *	30.65 ***	0.23 ns	6.25 ***	1.02 ns
	Capitella capitata	1.15 ns	2.34 ns	0.20 ns	12.32 ***	1.17 ns
	Bivalvia	0.92 ns	45.78 ***	0.41 ns	11.10 ***	0.57 ns
	Mya truncata	1.10 ns	85.62 ***	0.37 ns	4.43 ***	0.58 ns
	Thyasirides spp.	0.52 ns	41.41 ***	0.23 ns	12.31 ***	1.54 ns
	Astarte borealis	0.22 ns	21.00 ***	0.19 ns	16.82 ***	1.08 ns
	Astarte montagui	0.05 ns	24.14 ***	0.02 ns	35.98 ***	1.53 ns
	Astarte juveniles	0.83 ns	38.90 ***	0.56 ns	12.37 ***	1.12 ns
	Musculus discors	0.15 ns	13.46 ***	0.45 ns	13.50 ***	0.74 ns
	Musculus juveniles	0.14 ns	12.51 ***	1.34 ns	6.92 ***	0.59 ns
	Gastropoda	1.18 ns	72.32 ***	0.30 ns	5.25 ***	1.11 ns
	Cingula castanea	2.42 ns	110.63 ***	0.39 ns	8.11 ***	0.67 ns
	Retusa obtusa	2.91 *	56.74 ***	0.57 ns	1.71 ns	1.30 ns
	Holothuroidea					
	Myriotrochus rinkii	1.62 ns	17.12 ***	0.77 ns	4.36 ***	1.35 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant ($P\leq0.05$), Transect (Bay) alone was used to test main effects.
[4] The Period x Bay term is the test of oil effects.

Appendix H. Three-factor analyses of variance for the biomasses and densities of major taxa and dominant species of infauna at 3 m depth in three bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. P-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

		Source of Variation and df[3]				
		Period 4,6 or 30	Bay 2,6 or 30	Period x Bay[4] 8,6 or 30	Transect (Bay) 6,314	Per x Trans (Bay) 24,314
Biomass	Total infauna	0.76 ns	52.16 ***	0.10 ns	18.78 ***	0.83 ns
	Polychaeta	1.14 ns	23.06 **	0.36 ns	4.84 ***	1.57 *
	Bivalvia	0.47 ns	33.23 ***	0.10 ns	17.02 ***	0.73 ns
	Mya truncata	0.39 ns	61.21 ***	0.27 ns	10.85 ***	1.04 ns
	Astarte borealis	0.06 ns	21.10 ***	0.03 ns	33.33 ***	0.92 ns
	Astarte montagui	0.02 ns	23.92 ***	0.06 ns	61.78 ***	1.52 ns
	Macoma calcarea	0.20 ns	10.88 ***	0.20 ns	19.42 ***	0.66 ns
Density	Total infauna	5.30 *	30.62 ***	0.42 ns	6.59 ***	1.70 *
	Polychaeta	25.89 ***	47.19 ***	2.25 ns	1.93 ns	2.19 **
	Pholoe minuta	4.25 ns	19.73 **	0.24 ns	5.21 ***	1.70 *
	Nereimyra punctata	2.42 ns	1.92 ns	0.32 ns	19.74 ***	1.37 ns
	Euchone analis	2.25 ns	30.72 ***	0.47 ns	6.60 ***	1.60 *
	Spio spp.	[5]	[5]	11.39 **	1.39 ns	2.42 ***
	Eteone longa	2.34 ns	16.65 ***	0.60 ns	4.32 ***	1.07 ns
	Chaetozone setosa	3.22 *	52.90 ***	0.87 ns	5.98 ***	1.35 ns
	Capitella capitata	0.84 ns	1.12 ns	0.38 ns	15.86 ***	1.50 ns
	Bivalvia	1.24 ns	70.38 ***	0.42 ns	14.36 ***	0.52 ns
	Mya truncata	0.65 ns	138.07 ***	0.35 ns	6.47 ***	0.49 ns
	Thyasiridae spp.	0.31 ns	85.59 ***	0.29 ns	12.64 ***	1.05 ns
	Astarte borealis	0.20 ns	43.37 ***	0.16 ns	19.06 ***	1.10 ns
	Astarte montagui	0.02 ns	34.05 ***	0.01 ns	48.84 ***	1.12 ns
	Astarte juvenilis	0.57 ns	56.84 ***	0.59 ns	16.92 ***	1.25 ns
	Musculus discors	0.70 ns	25.99 ***	1.34 ns	4.65 ***	1.38 ns
	Musculus juvenilis	2.44 ns	24.51 ***	1.82 ns	3.47 **	0.85 ns
	Gastropoda	2.55 ns	196.10 ***	0.36 ns	3.19 **	1.20 ns
	Cingula castanea	4.71 **	396.37 ***	0.80 ns	4.85 ***	0.70 ns
	Retusa obtusa	8.90 ***	155.57 ***	1.14 ns	0.23 ns	1.14 ns
	Holothuroidea					
	Myriotrochus rinkii	7.53 ***	32.23 ***	1.88 ns	4.06 ***	0.75 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 11 (surface oil release).

[2] Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.

[4] The Period x Bay term is the test of oil effects.

[5] Interpretation of main effects confounded by significant interaction of Period x Bay term.

Appendix I. Three-factor analyses of variance for the biomasses and densities of major taxa and dominant species of infauna at 7 m depth in three bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and August and September 1981 and 1982[2]. Transects are nested within bays. P-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

		Source of Variation and df[3]				
		Period 4,6 or 30	Bay 2,6 or 30	Period x Bay[4] 8,6 or 30	Transect (Bay) 6,313	Per x Trans (Bay) 24,313
Biomass	Total infauna	2.64 ns	8.60 **	1.19 ns	1.33 ns	1.12 ns
	Polychaeta	3.85 *	1.27 ns	0.52 ns	3.58 **	1.02 ns
	Bivalvia	2.26 ns	9.02 ***	1.25 ns	1.23 ns	1.12 ns
	Mya truncata	2.37 ns	7.36 **	2.10 ns	1.12 ns	0.65 ns
	Astarte borealis	0.63 ns	7.30 **	1.00 ns	2.64 *	0.92 ns
	Astarte montagui	0.35 ns	59.11 ***	0.45 ns	3.45 **	0.87 ns
	Macoma calcarea	2.97 *	26.29 ***	0.29 ns	0.62 ns	1.52 ns
	Serripes groenlandicus	0.88 ns	56.48 ***	0.53 ns	3.74 **	0.84 ns
Density	Total infauna	10.00 ***	15.63 ***	0.81 ns	1.43 ns	1.36 ns
	Polychaeta	-5	-5	3.47 **	2.71 *	0.96 ns
	Pholoe minuta	11.29 ***	29.26 ***	0.96 ns	3.43 **	0.76 ns
	Pectinaria granulata	0.45 ns	3.05 ns	0.69 ns	6.02 ***	1.36 ns
	Praxillella praetermissa	3.60 *	4.24 *	0.30 ns	2.20 *	0.97 ns
	Spio spp.	33.12 ***	36.70 ***	1.83 ns	1.14 ns	1.36 ns
	Capitella capitata	3.21 *	0.01 ns	0.99 ns	4.08 ***	0.98 ns
	Maldane sarsi	0.21 ns	15.44 ***	0.41 ns	9.43 ***	1.28 ns
	Bivalvia	1.69 ns	15.38 **	0.30 ns	1.85 ns	1.77 *
	Mya truncata	2.93 *	8.62 **	0.47 ns	3.38 **	1.35 ns
	Thyasiridae spp.	2.18 ns	282.31 ***	0.27 ns	2.23 *	1.26 ns
	Astarte borealis	1.18 ns	3.58 *	0.50 ns	3.86 ***	1.26 ns
	Astarte montagui	0.36 ns	40.05 ***	0.30 ns	4.43 ***	1.28 ns
	Astarte juveniles	0.82 ns	24.51 ***	1.07 ns	1.20 ns	1.12 ns
	Macoma calcarea	4.09 ns	106.46 ***	1.04 ns	1.14 ns	2.16 ***
	Macoma juveniles	4.52 **	6.05 **	1.79 ns	1.69 ns	1.12 ns
	Nuculana minuta	1.97 ns	45.03 ***	1.36 ns	3.91 ***	0.52 ns
	Musculus niger	0.51 ns	46.45 ***	0.29 ns	4.78 ***	0.40 ns
	Musculus juveniles	6.72 ***	54.51 ***	0.43 ns	5.79 ***	0.42 ns
	Serripes groenlandicus	0.95 ns	49.10 ***	0.40 ns	3.54 **	1.16 ns
	Gastropoda	5.85 **	32.97 ***	0.89 ns	1.69 ns	0.92 ns
	Cingula castanea	2.84 *	18.89 ***	1.67 ns	2.58 *	1.10 ns
	Trichotropis borealis	0.93 ns	36.00 ***	0.89 ns	2.06 ns	0.65 ns
	Retusa obtusa	4.69 **	4.01 *	1.98 ns	2.18 *	0.99 ns
	Onollecia costulata	7.53 ***	53.90 ***	1.16 ns	1.62 ns	0.58 ns

[1] Bay 9 (dispersed oil releases), Bay 10 (dispersed oil contamination), Bay 11 (surface oil releases).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.

[4] The Period x Bay term is the test of oil effects.

[5] Interpretation of main effects confounded by significant interaction of Period x Bay term.

Appendix J. Three-factor analyses of variance for the biomasses and densities of major taxa and dominant species of infauna at 7 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

		Source of Variation and df[3]				
		Period 4,6 or 30	Bay 2,6 or 32	Period x Bay[4] 8,6 or 32	Transect (Bay) 6,334	Per x Trans (Bay) 24,334
Biomass	Total infauna	0.51 ns	5.54 **	0.70 ns	3.33 **	0.76 ns
	Polychaeta	1.13 ns	3.58 *	0.52 ns	2.64 **	0.90 ns
	Bivalvia	0.53 ns	5.55 **	0.61 ns	3.30 **	0.81 ns
	Mya truncata	0.68 ns	1.48 ns	0.89 ns	2.44 *	0.59 ns
	Astarte borealis	0.47 ns	46.20 ***	1.20 ns	1.68 ns	0.81 ns
	Astarte montagui	0.44 ns	91.66 ***	0.29 ns	4.19 ***	0.77 ns
	Macoma calcarea	2.48 ns	16.69 ***	0.26 ns	3.54 ***	1.11 ns
	Serripes groenlandicus	1.63 ns	29.43 ***	0.39 ns	2.53 *	0.80 ns
Density	Total infauna	14.38 ***	14.53 ***	1.13 ns	1.62 ns	1.08 ns
	Polychaeta	-[5]	-[5]	2.70 *	2.66 **	1.09 ns
	Pholoe minuta	8.16 ***	20.46 ***	1.72 ns	2.78 **	0.92 ns
	Pectinaria granulata	0.62 ns	1.28 ns	0.26 ns	7.14 ***	1.17 ns
	Praxillella praetermissa	7.71 ***	11.61 ***	0.40 ns	1.85 ns	1.14 ns
	Spio spp.	36.72 ***	24.77 ***	1.90 ns	2.48 *	1.12 ns
	Capitella capitata	6.16 **	0.13 ns	0.86 ns	2.35 *	1.08 ns
	Maldane sarsi	0.14 ns	9.65 ***	0.52 ns	6.15 ***	1.21 ns
	Bivalvia	1.89 ns	11.40 ***	0.29 ns	2.47 *	1.21 ns
	Mya truncata	1.52 ns	6.66 **	0.34 ns	2.95 **	0.95 ns
	Thyasiridae spp.	1.66 ns	83.17 ***	0.20 ns	5.01 ***	0.94 ns
	Astarte borealis	0.03 ns	24.96 ***	0.86 ns	1.99 *	0.79 ns
	Astarte montagui	0.24 ns	71.51 ***	0.37 ns	5.01 ***	1.08 ns
	Astarte juveniles	0.99 ns	50.52 ***	0.41 ns	1.04 ns	1.31 ns
	Macoma calcarea	1.43 ns	33.99 ***	0.71 ns	3.79 ***	1.35 ns
	Macoma juveniles	4.08 *	9.38 ***	1.90 ns	2.49 *	0.81 ns
	Nuculana minuta	1.73 ns	30.71 ***	0.55 ns	2.01 *	0.83 ns
	Musculus niger	0.51 ns	34.01 ***	0.27 ns	2.47 *	0.38 ns
	Musculus juveniles	8.70 ***	26.92 ***	0.30 ns	5.24 ***	0.34 ns
	Serripes groenlandicus	0.79 ns	27.21 ***	0.25 ns	2.37 *	1.15 ns
	Gastropoda	5.12 **	23.77 ***	1.09 ns	2.32 *	0.80 ns
	Cingula castanea	3.04 *	21.72 ***	1.56 ns	2.79 **	0.94 ns
	Trichotropis borealis	0.86 ns	13.47 ***	0.48 ns	3.15 **	0.64 ns
	Retusa obtusa	1.84 ns	1.94 ns	1.45 ns	2.56 *	1.04 ns
	Moelleria costulata	7.10 ***	35.86 ***	1.40 ns	1.36 ns	0.65 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.

[4] The Period x Bay term is the test of oil effects.

[5] Interpretation of main effects confounded by significant interaction of Period x Bay term.

Appendix K. Three-factor analyses of variance for the biomasses and densities of major taxa and dominant species of infauna at 7 m depth in three bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

		Source of Variation and df[3]				
		Period 4,6 or 30	Bay 2,6 or 30	Period x Bay[4] 8,6 or 30	Transect (Bay) 6,314	Per x Trans (Bay) 24,314
Biomass	Total infauna	1.98 ns	9.96 ***	0.65 ns	3.61 **	1.06 ns
	Polychaeta	1.22 ns	5.87 **	0.57 ns	2.52 *	0.74 ns
	Bivalvia	1.91 ns	9.63 ***	0.56 ns	3.83 **	1.06 ns
	Mya truncata	3.21 *	2.55 ns	0.31 ns	3.53 **	0.79 ns
	Astarte borealis	0.93 ns	94.16 ***	0.98 ns	1.53 ns	0.98 ns
	Astarte montagui	0.11 ns	101.67 ***	0.16 ns	3.16 **	1.60 *
	Macoma calcarea	2.20 ns	32.12 ***	0.25 ns	4.36 ***	1.14 ns
	Serripes groenlandicus	1.11 ns	81.18 ***	0.63 ns	0.94 ns	0.86 ns
Density	Total infauna	11.34 ***	18.93 ***	0.73 ns	1.09 ns	1.43 ns
	Polychaeta	29.71 ***	14.86 ***	1.50 ns	2.27 *	1.30 ns
	Pholoe minuta	22.44 ***	43.77 ***	1.65 ns	1.77 ns	1.28 ns
	Pectinaria granulata	0.72 ns	0.69 ns	0.20 ns	8.21 ***	1.18 ns
	Praxillella praetermissa	7.53 ***	20.37 ***	0.69 ns	1.05 ns	1.13 ns
	Spio spp.	4.73 ns	21.66 ***	1.81 ns	1.99 ns	1.69 *
	Capitella capitata	6.03 **	0.64 ns	1.02 ns	4.21 ***	0.87 ns
	Maldane sarsi	0.65 ns	13.53 ***	0.75 ns	7.74 ***	0.86 ns
	Bivalvia	1.51 ns	17.65 ***	0.33 ns	2.18 *	1.14 ns
	Mya truncata	0.68 ns	8.64 **	0.26 ns	3.32 **	0.95 ns
	Thyasiridae spp.	1.20 ns	166.40 ***	0.40 ns	5.65 ***	0.62 ns
	Astarte borealis	0.14 ns	36.92 ***	0.74 ns	3.03 **	0.86 ns
	Astarte montagui	0.06 ns	62.97 ***	0.19 ns	4.68 ***	1.72 *
	Astarte juveniles	1.13 ns	90.60 ***	0.42 ns	1.20 ns	1.36 ns
	Macoma calcarea	0.61 ns	55.64 ***	0.69 ns	4.83 ***	1.24 ns
	Macoma juveniles	-[5]	-[5]	2.92 *	1.92 ns	0.56 ns
	Nuculana minuta	1.12 ns	24.71 ***	0.50 ns	2.92 **	1.14 ns
	Musculus niger	1.38 ns	68.12 ***	1.02 ns	1.25 ns	0.39 ns
	Musculus juveniles	5.42 **	29.99 ***	0.61 ns	4.30 ***	0.60 ns
	Serripes groenlandicus	1.47 ns	59.54 ***	0.41 ns	1.45 ns	1.00 ns
	Gastropoda	2.20 ns	15.61 ***	1.05 ns	2.55 *	0.98 ns
	Cingula castanea	1.86 ns	31.47 ***	2.01 ns	2.36 *	0.83 ns
	Trichotropis borealis	0.52 ns	20.56 ***	0.60 ns	3.67 **	0.60 ns
	Retusa obtusa	2.64 ns	3.49 *	1.10 ns	1.71 ns	1.24 ns
	Moelleria costulata	2.18 ns	12.92 ***	0.92 ns	1.85 ns	1.03 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 11 (surface oil release).

[2] Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.

[4] The Period x Bay term is the test of oil effects.

[5] Interpretation of main effects confounded by significant interaction of Period x Bay term.

APPENDIX L. Multivariate and univariate analyses of variance (MANOVA and ANOVA) for factor scores determined in factor analyses of infaunal density in three bays[1] at Cape Hatt, northern Baffin Island, during September 1980, and August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001) for univariate analyses, and with actual probabilities for multivariate analyses.

Depth	Variable		Source of Variation and Univariate df[3]				
			Period 4,30	Bay 2,30	Period x Bay[4] 8,30	Transect (Bay) 6,313	Per x Trans (Bay) 24,313
3 m	**MANOVA**						
	Pillai's trace	F ->	2.53	53.18	0.87	15.25	1.13
		P ->	0.001	0.000	0.694	0.000	0.167
		df ->	20,116	10,54	40,150	30,1565	120,1565
	ANOVAS						
	Factor 1		1.40 ns	135.57 ***	1.18 ns	12.65 ***	1.21 ns
	Factor 2		0.62 ns	27.36 ***	0.15 ns	19.30 ***	1.34 ns
	Factor 3		0.39 ns	20.44 ***	0.53 ns	20.32 ***	0.98 ns
	Factor 4		8.20 ***	13.84 ***	0.37 ns	21.06 ***	1.24 ns
	Factor 5		1.82 ns	1.44 ns	0.51 ns	14.66 ***	0.83 ns
7 m	**MANOVA**						
	Pillai's trace	F ->	2.20	32.01	0.86	3.85	1.12
		P ->	0.003	0.000	0.722	0.000	0.162
		df ->	24,112	12,52	48,180	36,1878	144,1878
	ANOVAS						
	Factor 1		0.86 ns	31.80 ***	0.35 ns	2.13 ns	1.33 ns
	Factor 2		1.29 ns	121.46 ***	0.39 ns	3.52 **	1.35 ns
	Factor 3		0.70 ns	17.41 ***	0.37 ns	10.46 ***	0.72 ns
	Factor 4		-5	-5	2.39 *	3.20 **	1.00 ns
	Factor 5		3.71 *	71.88 ***	2.12 ns	1.09 ns	1.05 ns
	Factor 6		0.21 ns	8.02 **	0.51 ns	4.83 ***	1.21 ns

1 Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
3 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.
4 The Period x Bay term is the test of oil effects.
5 Interpretation of main effects confounded by significant interaction of Period x Bay term.

APPENDIX M. Multivariate and univariate analyses of variance (MANOVA and ANOVA) for factor scores determined in factor analyses of infaunal density in four bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001) for univariate analyses, and with actual probabilities for multivariate analyses.

			Source of Variation and Univariate df[3]				
Depth	Variable		Period 3,32	Bay 3,32	Period x Bay[4] 9,32	Transect (Bay) 8,334	Per x Trans (Bay) 24,334
3 m	**MANOVA**						
	Pillai's trace	F ->	3.75	34.10	0.75	10.80	1.06
		P ->	0.000	0.000	0.867	0.000	0.327
		df ->	15,90	15,90	45,160	40,1670	120,1670
	ANOVAS						
	Factor 1		2.30 ns	105.93 ***	0.43 ns	8.27 ***	1.29 ns
	Factor 2		2.63 ns	15.98 ***	0.65 ns	14.27 ***	1.44 ns
	Factor 3		0.16 ns	11.47 ***	0.54 ns	15.23 ***	0.66 ns
	Factor 4		15.93 ***	17.00 ***	0.25 ns	15.07 ***	1.11 ns
	Factor 5		4.70 **	13.22 ***	0.22 ns	9.02 ***	0.88 ns
7 m	**MANOVA**						
	Pillai's trace	F ->	2.38	24.83	0.87	3.5	1.11
		P ->	0.004	0.000	0.728	0.0	0.185
		df ->	18,87	18,87	54,192	48,2	144,2004
	ANOVAS						
	Factor 1		0.53 ns	84.64 ***	0.36 ns	1.46 ns	1.13 ns
	Factor 2		0.35 ns	38.20 ***	0.50 ns	6.34 ***	1.03 ns
	Factor 3		1.48 ns	8.96 ***	0.28 ns	7.90 ***	0.80 ns
	Factor 4		46.42 ***	10.88 ***	1.81 ns	1.92 ns	1.40 ns
	Factor 5		1.59 ns	52.45 ***	1.64 ns	2.06 *	1.05 ns
	Factor 6		0.81 ns	4.96 **	0.39 ns	5.58 ***	1.36 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.
[4] The Period x Bay term is the test of oil effects.

APPENDIX N. Multivariate and univariate analyses of variance (MANOVA and ANOVA) for factor scores determined in factor analyses of infaunal density in three bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982 and during August 1983[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001) for univariate analyses, and with actual probabilities for multivariate analyses.

			Source of Variation and Univariate df[3]				
Depth	Variable		Period 4,30	Bay 2,30	Period x Bay[4] 8,30	Transect (Bay) 6,314	Per x Trans (Bay) 24,314
3 m	**MANOVA**						
	Pillai's trace	F ->	1.11	205.14	0.66	10.51	1.23
		P ->	0.411	0.000	0.888	0.000	0.0498
		df ->	20,20	10,6	40,30	30,1570	120,1570
	ANOVAS						
	Factor 1		1.41 ns	143.53 ***	0.53 ns	11.18 ***	1.47 ns
	Factor 2		8.97 ***	18.40 ***	1.14 ns	19.85 ***	1.43 ns
	Factor 3		3.08 *	19.90 ***	1.58 ns	7.69 ***	1.03 ns
	Factor 4		19.49 ***	39.86 ***	0.57 ns	13.79 ***	1.09 ns
	Factor 5		7.12 ***	28.46 ***	0.27 ns	6.47 ***	1.05 ns
7 m	**MANOVA**						
	Pillai's trace	F ->	1.98	78.37	0.94	3.94	1.11
		P ->	0.009	0.000	0.596	0.000	0.185
		df ->	24,112	12,52	48,180	36,1884	144,1884
	ANOVAS						
	Factor 1		0.36 ns	135.50 ***	0.28 ns	1.54 ns	1.33 ns
	Factor 2		0.09 ns	67.69 ***	0.63 ns	7.81 ***	0.83 ns
	Factor 3		1.39 ns	9.84 ***	0.61 ns	7.20 ***	0.86 ns
	Factor 4		37.09 ***	2.58 ns	1.30 ns	2.64 *	1.54 ns
	Factor 5		0.37 ns	40.57 ***	1.41 ns	2.62 *	1.01 ns
	Factor 6		0.75 ns	8.30 **	0.47 ns	6.96 ***	1.29 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 11 (surface oil release).
[2] Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).
[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.
[4] The Period x Bay term is the test of oil effects.

APPENDIX O. Mean biomass (g/m^2) of infaunal animals[1] according to major feeding mode in four bays[2] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[3]. Data are expressed as mean ± standard deviation and are based on 8 replicate 0.0625 m^2 airlift samples on each of three transects for each depth, period and bay.

		3 m Depth				7 m Depth			
	Period	Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Carnivores	Pre-spill 1	-	19.0 ± 17.3	12.2 ± 9.6	7.9 ± 6.3	-	15.5 ± 27.0	17.9 ± 49.3	14.4 ± 30.5
	Pre-spill 2	18.6 ± 38.6	13.2 ± 12.7	10.5 ± 7.3	10.7 ± 5.9	20.0 ± 45.3	25.8 ± 38.8	32.9 ± 75.6	28.3 ± 68.7
	Post-spill 1	14.4 ± 12.9	14.8 ± 10.9	17.9 ± 18.0	18.8 ± 15.8	44.3 ± 72.6	16.1 ± 24.0	14.2 ± 24.5	7.8 ± 10.9
	Post-spill 2	17.5 ± 44.0	15.5 ± 29.9	12.5 ± 11.9	11.8 ± 7.2	32.7 ± 69.3	30.0 ± 50.7	7.7 ± 6.5	27.9 ± 48.6
	Post-spill 3	22.1 ± 49.1	23.8 ± 21.9	11.3 ± 22.3	9.8 ± 7.6	74.5 ± 149.2	39.2 ± 67.7	23.0 ± 51.0	16.3 ± 30.8
	Post-spill 4	15.8 ± 17.3	22.8 ± 19.4	-	15.3 ± 16.5	37.8 ± 54.1	58.2 ± 114.2	-	32.6 ± 61.8
Filter feeders	Pre-spill 1	-	517.2 ± 383.9	260.0 ± 217.1	53.9 ± 80.9	-	2070.5 ± 1043.2	1349.7 ± 584.2	1052.8 ± 615.9
	Pre-spill 2	133.8 ± 160.9	589.3 ± 448.7	292.9 ± 252.2	34.3 ± 57.4	711.7 ± 597.2	1203.2 ± 807.3	1027.0 ± 653.6	1211.3 ± 757.0
	Post-spill 1	192.2 ± 188.1	807.5 ± 677.4	415.4 ± 373.9	47.0 ± 85.2	998.5 ± 594.7	1109.8 ± 561.0	1029.4 ± 567.8	1109.6 ± 725.8
	Post-spill 2	209.9 ± 236.7	788.4 ± 547.8	402.5 ± 425.0	66.0 ± 96.0	906.3 ± 812.6	1469.8 ± 818.0	1030.4 ± 817.9	1106.5 ± 511.9
	Post-spill 3	168.3 ± 186.2	815.8 ± 582.6	363.3 ± 308.9	43.5 ± 71.0	826.1 ± 605.5	1642.0 ± 974.4	1061.5 ± 733.0	1296.4 ± 814.2
	Post-spill 4	284.3 ± 381.6	971.0 ± 861.9	-	38.5 ± 44.1	982.9 ± 502.6	1877.0 ± 934.4	-	1458.5 ± 853.7
Deposit feeders	Pre-spill 1	-	26.1 ± 12.2	20.0 ± 18.2	14.3 ± 14.7	-	34.8 ± 25.5	38.3 ± 28.0	37.7 ± 23.3
	Pre-spill 2	16.5 ± 22.7	28.7 ± 16.8	16.8 ± 13.2	11.5 ± 11.0	28.3 ± 33.7	36.8 ± 27.3	38.4 ± 41.8	31.3 ± 30.2
	Post-spill 1	11.0 ± 8.7	27.6 ± 15.7	21.9 ± 9.9	11.2 ± 9.8	33.5 ± 31.3	28.0 ± 16.4	29.6 ± 23.6	25.2 ± 14.8
	Post-spill 2	18.3 ± 30.9	26.4 ± 14.7	17.8 ± 18.5	8.8 ± 7.6	31.4 ± 34.9	28.8 ± 27.4	27.2 ± 14.3	27.6 ± 20.1
	Post-spill 3	14.5 ± 24.5	26.3 ± 15.7	12.4 ± 9.0	9.1 ± 8.4	47.8 ± 63.5	43.1 ± 36.7	33.9 ± 36.0	27.7 ± 17.3
	Post-spill 4	15.7 ± 9.3	32.1 ± 13.8	-	21.3 ± 13.3	29.1 ± 32.0	48.5 ± 56.3	-	27.6 ± 22.8
Surface deposit feeders	Pre-spill 1	-	21.0 ± 23.9	10.1 ± 8.6	3.5 ± 7.7	-	158.1 ± 104.6	103.9 ± 43.8	119.5 ± 126.8
	Pre-spill 2	5.3 ± 8.7	29.6 ± 30.6	13.4 ± 24.3	0.4 ± 0.9	243.8 ± 162.0	221.3 ± 199.1	123.6 ± 84.4	92.7 ± 97.6
	Post-spill 1	10.1 ± 16.4	30.9 ± 33.5	24.6 ± 83.5	3.2 ± 8.3	243.2 ± 188.7	152.7 ± 121.9	113.7 ± 84.9	69.5 ± 35.8
	Post-spill 2	8.8 ± 12.9	21.1 ± 19.9	33.7 ± 74.2	1.0 ± 1.7	239.1 ± 159.5	206.8 ± 122.0	146.4 ± 98.6	72.8 ± 45.6
	Post-spill 3	8.4 ± 10.3	32.5 ± 29.5	13.5 ± 19.3	4.9 ± 12.0	254.2 ± 177.0	212.8 ± 254.7	118.6 ± 65.0	89.6 ± 49.7
	Post-spill 4	51.1 ± 122.3	27.5 ± 27.0	-	3.3 ± 7.9	271.5 ± 266.3	211.4 ± 173.2	-	101.9 ± 56.2
Total	Pre-spill 1	-	583.3 ± 402.9	302.4 ± 232.8	79.6 ± 96.5	-	2279.0 ± 1042.7	1509.8 ± 576.8	1224.5 ± 644.9
	Pre-spill 2	174.2 ± 182.7	660.8 ± 475.3	333.6 ± 269.0	56.9 ± 61.1	1003.8 ± 668.8	1487.0 ± 900.7	1221.9 ± 653.1	1363.6 ± 778.3
	Post-spill 1	227.7 ± 201.4	880.7 ± 695.0	479.8 ± 366.5	80.3 ± 93.2	1319.5 ± 636.2	1306.6 ± 640.7	1186.9 ± 596.1	1212.0 ± 742.7
	Post-spill 2	254.6 ± 269.9	851.3 ± 560.3	466.5 ± 467.2	87.5 ± 98.0	1209.4 ± 859.3	1735.4 ± 864.3	1211.7 ± 827.1	1234.7 ± 516.4
	Post-spill 3	213.3 ± 210.7	898.4 ± 588.5	400.5 ± 324.8	67.3 ± 79.4	1202.7 ± 701.8	1937.1 ± 920.2	1236.9 ± 742.5	1430.0 ± 834.0
	Post-spill 4	366.9 ± 493.4	1053.3 ± 881.8	-	78.4 ± 52.0	1321.3 ± 531.2	2195.0 ± 888.8	-	1620.7 ± 879.8

[1] Wet weight including bivalve shells; does not include gastropods or other animals that were not classified into feeding guilds.
[2] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[3] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

APPENDIX P. Three-factor analyses of variance for biomass of animals according to feeding mode in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. P-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

Analysis	Depth	Feeding Guild/df[3]	Source of Variation				
			Period	Bay	Period x Bay[4]	Transect (Bay)[3]	Per x Trans (Bay)[3]
Bays 9, 10, 11/ 1980-1982	3 m	Carnivores	1.30 ns	2.75 ns	1.47 ns	3.37 **	1.46 ns
		Filter feeders	0.38 ns	62.10 ***	0.20 ns	14.83 ***	1.07 ns
		Deposit feeders	0.80 ns	22.69 ***	0.28 ns	7.76 ***	1.53 ns
		Surface-deposit feeders	0.18 ns	18.11 ***	0.43 ns	16.65 ***	0.98 ns
	7 m	Carnivores	1.47 ns	2.66 ns	0.66 ns	0.17 ns	1.02 ns
		Filter feeders	2.27 ns	7.51 **	1.51 ns	1.28 ns	1.05 ns
		Deposit feeders	1.55 ns	0.51 ns	0.35 ns	2.67 *	1.05 ns
		Surface-deposit feeders	0.96 ns	33.27 ***	0.76 ns	1.61 ns	1.22 ns
		Degrees of freedom	4,30	2,30	8,30	6,313	24,313
Bays 7, 9, 10, 11/ 1981, 1982	3 m	Carnivores	1.07 ns	0.57 ns	0.67 ns	4.44 ***	1.29 ns
		Filter feeders	0.46 ns	35.73 ***	0.07 ns	11.15 ***	0.91 ns
		Deposit feeders	0.31 ns	8.17 **	0.22 ns	4.49 ***	1.64 *
		Surface-deposit feeders	0.29 ns	14.35 ***	0.40 ns	10.34 ***	0.88 ns
	7 m	Carnivores	0.94 ns	3.11 *	0.83 ns	1.92 ns	1.01 ns
		Filter feeders	0.40 ns	7.52 ***	0.64 ns	3.06 **	0.79 ns
		Deposit feeders	1.60 ns	0.73 ns	0.61 ns	1.66 ns	0.77 ns
		Surface-deposit feeders	0.78 ns	29.75 ***	0.27 ns	1.45 ns	1.61 *
		Degrees of freedom	3,8 or 32	3,8 or 32	9,8 or 32	8,334	24,334
Bays 7, 10, 11/ 1981-1983	3 m	Carnivores	1.01 ns	1.25 ns	0.61 ns	5.49 ***	1.26 ns
		Filter feeders	0.43 ns	53.94 ***	0.11 ns	17.18 ***	0.75 ns
		Deposit feeders	2.94 *	39.02 ***	0.65 ns	2.53 *	1.24 ns
		Surface-deposit feeders	1.06 ns	22.11 ***	0.70 ns	16.29 ***	0.68 ns
	7 m	Carnivores	1.01 ns	2.66 ns	0.56 ns	2.88 **	1.10 ns
		Filter feeders	1.84 ns	12.88 ***	0.58 ns	3.50 **	1.01 ns
		Deposit feeders	1.54 ns	2.85 ns	1.05 ns	1.22 ns	0.70 ns
		Surface-deposit feeders	1.65 ns	81.58 ***	0.47 ns	0.89 ns	1.59 *
		Degrees of freedom	4,6 or 30	2,6 or 30	8,6 or 30	6,314	24,314

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).

[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.

[4] The Period x Bay term is the test of oil effects.

Appendix Q. Mean density (no./m^2) of major taxa and dominant species of epibenthic crustaceans in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981, 1982 and August 1983[2]. Data are expressed as mean ± standard deviation and are based on 8 replicate 0.0625 m^2 airlift samples on each of three transects for each depth, period and bay.

Taxon	Period[2]	3 m Depth				7 m Depth			
		Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Total Epibenthos	Pre-spill 1	-	302.0 ± 186.8	437.3 ± 311.5	306.7 ± 188.8	-	1390.0 ± 869.0	2523.3 ± 961.0	2084.7 ± 815.2
	Pre-spill 2	206.7 ± 123.5	440.0 ± 689.4	298.0 ± 292.0	248.8 ± 306.6	2526.7 ± 957.3	2138.7 ± 857.2	1900.5 ± 669.3	1963.3 ± 1269.3
	Post-spill 1	275.3 ± 182.2	869.3 ± 803.6	432.0 ± 382.6	338.4 ± 397.9	2658.7 ± 651.9	2237.3 ± 1290.9	2235.5 ± 847.1	1759.7 ± 1090.6
	Post-spill 2	347.4 ± 246.7	601.3 ± 549.7	674.0 ± 414.2	422.5 ± 445.3	3201.6 ± 1191.1	3040.7 ± 1388.9	4879.6 ± 9563.4	2613.3 ± 1345.9
	Post-spill 3	514.0 ± 307.5	526.0 ± 213.3	813.0 ± 668.0	411.9 ± 237.7	3526.7 ± 1585.0	3196.0 ± 1450.5	3115.6 ± 1263.0	2765.3 ± 1161.3
	Post-spill 4	778.7 ± 445.6	726.0 ± 446.2	-	447.1 ± 502.3	3810.0 ± 1100.3	3544.7 ± 1251.0	-	2953.8 ± 1723.3
Ostracods	Pre-spill 1	-	50.7 ± 51.2	46.0 ± 101.4	10.0 ± 15.5	-	977.3 ± 736.6	1741.3 ± 864.0	1144.0 ± 726.6
	Pre-spill 2	10.0 ± 19.9	49.3 ± 87.2	13.9 ± 18.2	3.3 ± 8.1	2103.3 ± 1030.7	1744.7 ± 746.4	1570.1 ± 621.0	1310.7 ± 973.6
	Post-spill 1	11.3 ± 16.0	284.7 ± 500.8	18.0 ± 29.6	37.0 ± 120.3	2279.3 ± 682.3	1841.3 ± 1212.2	1785.5 ± 778.3	1097.3 ± 899.1
	Post-spill 2	16.7 ± 26.5	91.3 ± 103.2	35.0 ± 52.2	8.7 ± 42.5	2673.9 ± 1137.4	2307.3 ± 897.1	2268.7 ± 1399.4	1727.7 ± 1285.8
	Post-spill 3	24.7 ± 25.4	94.7 ± 121.4	32.7 ± 41.5	11.3 ± 16.7	2912.0 ± 1448.7	2622.0 ± 1293.8	2251.1 ± 1064.5	1622.7 ± 967.6
	Post-spill 4	44.4 ± 37.9	235.3 ± 296.6	-	30.2 ± 64.6	3117.3 ± 972.8	2876.7 ± 1092.4	-	1593.3 ± 1366.2
Mysidacea spp.	Pre-spill 1	-	18.0 ± 26.0	30.7 ± 94.0	4.7 ± 10.0	-	965.3 ± 740.9	1726.0 ± 887.9	1099.3 ± 751.9
	Pre-spill 2	9.3 ± 19.4	19.3 ± 27.1	11.8 ± 15.4	2.7 ± 7.7	2102.0 ± 1031.3	1742.7 ± 747.4	1570.1 ± 621.0	1308.7 ± 971.4
	Post-spill 1	10.7 ± 15.4	34.0 ± 44.8	16.0 ± 29.8	9.2 ± 25.7	2278.7 ± 682.2	1837.3 ± 1212.9	1783.5 ± 777.8	1096.7 ± 898.5
	Post-spill 2	16.7 ± 26.5	26.0 ± 37.1	17.3 ± 27.3	0	2673.9 ± 1137.4	2302.7 ± 894.6	2268.7 ± 1399.4	1727.7 ± 1285.8
	Post-spill 3	20.7 ± 21.4	35.3 ± 27.1	27.3 ± 36.1	10.0 ± 16.2	2905.3 ± 1450.9	2615.3 ± 1293.0	2250.5 ± 1064.3	1621.3 ± 968.3
	Post-spill 4	20.0 ± 19.0	11.3 ± 12.9	-	1.3 ± 4.5	3115.3 ± 972.8	2862.0 ± 1102.3	-	1590.0 ± 1365.3
Cumacea	Pre-spill 1	-	26.7 ± 36.4	38.0 ± 84.9	10.7 ± 27.8	-	142.0 ± 110.0	135.3 ± 96.8	319.3 ± 169.4
	Pre-spill 2	18.7 ± 30.8	140.7 ± 375.6	20.8 ± 33.0	24.0 ± 48.6	72.7 ± 68.0	96.0 ± 94.0	55.7 ± 40.9	214.0 ± 155.5
	Post-spill 1	36.7 ± 43.1	94.7 ± 98.5	118.0 ± 177.4	5.6 ± 11.4	31.3 ± 33.9	135.3 ± 80.3	51.1 ± 38.6	186.4 ± 124.0
	Post-spill 2	15.3 ± 21.9	190.0 ± 292.3	64.7 ± 112.8	57.3 ± 113.1	103.3 ± 96.3	166.7 ± 169.6	96.0 ± 96.9	294.7 ± 157.0
	Post-spill 3	22.0 ± 62.9	72.0 ± 74.9	58.0 ± 171.6	12.0 ± 23.7	82.0 ± 55.1	113.3 ± 103.3	99.7 ± 90.0	278.0 ± 165.0
	Post-spill 4	12.0 ± 25.5	74.0 ± 112.9	-	5.3 ± 16.8	159.3 ± 148.0	167.3 ± 122.2	-	444.0 ± 313.0
Lamprops fuscata	Pre-spill 1	-	24.0 ± 36.2	22.7 ± 62.4	10.7 ± 27.8	-	108.7 ± 98.4	110.0 ± 86.0	192.0 ± 146.0
	Pre-spill 2	18.7 ± 30.8	139.3 ± 376.0	20.8 ± 33.0	23.3 ± 48.8	59.3 ± 61.8	83.3 ± 94.5	40.3 ± 36.4	104.7 ± 97.7
	Post-spill 1	36.0 ± 43.6	91.3 ± 96.7	117.3 ± 176.3	4.9 ± 8.9	25.3 ± 29.1	117.3 ± 76.2	28.7 ± 25.8	93.6 ± 81.3
	Post-spill 2	15.3 ± 21.9	189.3 ± 290.3	64.0 ± 112.0	50.7 ± 102.5	84.0 ± 79.7	149.3 ± 162.6	82.7 ± 93.9	165.3 ± 126.3
	Post-spill 3	21.3 ± 63.1	69.3 ± 73.8	56.0 ± 170.0	11.3 ± 23.8	72.0 ± 51.0	96.7 ± 103.0	89.3 ± 90.5	142.0 ± 102.4
	Post-spill 4	12.0 ± 25.5	74.0 ± 112.9	-	5.3 ± 16.8	141.3 ± 142.1	156.0 ± 118.5	-	262.7 ± 213.3
Amphipoda	Pre-spill 1	-	224.7 ± 141.7	353.3 ± 267.6	286.0 ± 178.9	-	270.7 ± 244.7	644.0 ± 369.0	600.0 ± 301.1
	Pre-spill 2	176.7 ± 110.4	248.0 ± 364.2	261.9 ± 272.2	218.2 ± 272.4	345.3 ± 224.5	296.0 ± 157.3	266.4 ± 99.4	426.0 ± 269.3
	Post-spill 1	225.3 ± 164.3	469.3 ± 455.9	296.0 ± 295.1	290.3 ± 374.4	344.0 ± 162.5	259.3 ± 107.0	391.7 ± 183.3	469.3 ± 241.3
	Post-spill 2	314.1 ± 227.7	320.0 ± 253.1	574.4 ± 367.0	356.5 ± 387.5	423.0 ± 232.2	561.3 ± 824.6	2497.6 ± 9464.9	587.6 ± 208.3
	Post-spill 3	466.0 ± 286.3	356.0 ± 156.6	721.6 ± 541.6	385.9 ± 224.1	532.0 ± 242.3	458.0 ± 178.3	747.7 ± 418.1	854.0 ± 570.4
	Post-spill 4	722.3 ± 432.9	416.7 ± 177.0	-	408.3 ± 497.3	526.7 ± 227.5	496.0 ± 236.0	-	909.8 ± 576.7
Gammaridea sp.[3]	Pre-spill 1	-	72.7 ± 63.3	43.3 ± 62.7	14.0 ± 25.5	-	92.0 ± 65.1	112.7 ± 78.9	163.3 ± 99.0
	Pre-spill 2	15.3 ± 19.2	98.0 ± 125.5	53.5 ± 45.9	11.3 ± 18.6	117.3 ± 48.7	179.3 ± 115.4	125.2 ± 73.6	196.7 ± 166.7
	Post-spill 1	39.3 ± 48.1	209.3 ± 141.8	77.3 ± 81.7	12.5 ± 15.2	98.7 ± 72.9	152.0 ± 79.2	187.9 ± 109.8	152.3 ± 89.4
	Post-spill 2	34.7 ± 35.2	116.7 ± 79.7	88.6 ± 100.2	24.7 ± 39.2	140.1 ± 86.6	271.3 ± 179.8	285.0 ± 214.5	285.2 ± 170.1
	Post-spill 3	32.7 ± 64.8	138.0 ± 56.0	35.8 ± 54.2	10.0 ± 19.2	179.3 ± 122.2	253.3 ± 108.1	255.0 ± 132.0	260.7 ± 125.2
	Post-spill 4	66.2 ± 49.9	209.3 ± 88.1	-	18.2 ± 23.0	198.7 ± 110.2	304.0 ± 176.2	-	352.8 ± 287.4

Continued...

1 Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).
3 Stenothoidae includes Metopella and Metopa; Calliopiidae includes Apherusa. Genera indicated include species listed in Appendix C.

Appendix Q. Concluded.

Taxon	Period[2]	3 m Depth				7 m Depth			
		Bay 7	Bay 9	Bay 10	Bay 11	Bay 7	Bay 9	Bay 10	Bay 11
Orchomene minuta	Pre-spill 1	–	5.3 ± 9.0	37.3 ± 59.4	8.7 ± 10.5	–	2.7 ± 7.7	6.7 ± 12.4	10.0 ± 27.0
	Pre-spill 2	17.3 ± 29.4	29.3 ± 44.2	70.7 ± 219.2	5.3 ± 19.8	4.7 ± 11.0	5.3 ± 10.2	11.1 ± 14.0	19.3 ± 23.6
	Post-spill 1	10.7 ± 25.3	27.3 ± 47.5	50.0 ± 214.6	3.8 ± 6.8	1.3 ± 4.5	3.3 ± 6.6	4.7 ± 12.0	16.3 ± 23.7
	Post-spill 2	16.7 ± 16.0	28.7 ± 65.7	73.3 ± 173.9	15.3 ± 45.6	8.7 ± 13.3	130.7 ± 572.9	1776.7 ± 8476.0	16.7 ± 18.6
	Post-spill 3	16.7 ± 23.3	9.3 ± 15.6	60.7 ± 81.3	12.0 ± 21.7	4.0 ± 11.8	0	4.7 ± 14.5	15.3 ± 26.0
	Post-spill 4	9.3 ± 13.3	8.0 ± 13.3	–	2.0 ± 5.4	9.3 ± 13.3	31.3 ± 56.1	–	44.7 ± 125.2
Ampe spp.[3]	Pre-spill 1	–	8.0 ± 11.6	18.0 ± 40.4	40.7 ± 97.3	–	91.3 ± 220.1	300.0 ± 307.7	95.3 ± 84.8
	Pre-spill 2	5.3 ± 10.2	2.0 ± 7.2	2.8 ± 6.2	7.3 ± 14.9	29.3 ± 56.9	29.3 ± 56.9	11.8 ± 19.4	26.0 ± 30.5
	Post-spill 1	24.0 ± 29.5	12.0 ± 17.2	6.7 ± 10.5	5.6 ± 10.4	30.7 ± 62.4	7.3 ± 10.5	33.3 ± 33.3	47.7 ± 50.4
	Post-spill 2	2.7 ± 6.1	1.3 ± 4.5	4.0 ± 9.7	66.0 ± 150.7	12.7 ± 24.5	62.0 ± 76.8	124.0 ± 138.3	53.3 ± 56.9
	Post-spill 3	72.0 ± 202.7	74.0 ± 75.9	157.3 ± 342.5	31.3 ± 38.5	16.7 ± 28.1	60.7 ± 76.8	124.0 ± 138.3	53.3 ± 56.9
	Post-spill 4	2.0 ± 7.2	0	–	1.3 ± 6.5	16.0 ± 15.6	22.0 ± 25.8	–	20.0 ± 20.7
Pontoporeia femorata	Pre-spill 1	–	3.3 ± 6.6	2.0 ± 5.4	15.3 ± 31.8	–	10.0 ± 16.2	2.7 ± 6.1	72.7 ± 92.3
	Pre-spill 2	3.3 ± 6.6	1.3 ± 4.5	4.2 ± 8.7	80.0 ± 181.1	72.0 ± 59.5	20.0 ± 26.4	9.7 ± 15.1	37.3 ± 90.0
	Post-spill 1	6.7 ± 11.5	7.3 ± 13.3	3.3 ± 8.1	13.2 ± 39.1	108.0 ± 71.7	39.3 ± 49.3	14.0 ± 17.8	82.8 ± 110.8
	Post-spill 2	12.0 ± 28.4	11.3 ± 29.6	5.3 ± 9.0	57.8 ± 148.1	136.0 ± 107.2	25.3 ± 33.3	22.7 ± 30.5	100.0 ± 137.1
	Post-spill 3	6.7 ± 10.5	9.3 ± 15.6	6.0 ± 10.4	52.7 ± 116.7	214.7 ± 151.9	57.3 ± 48.3	23.3 ± 35.9	172.0 ± 299.4
	Post-spill 4	13.3 ± 27.4	30.0 ± 46.3	–	16.0 ± 29.5	170.0 ± 142.3	43.3 ± 43.4	–	150.7 ± 178.1
Monoculodes spp.[3]	Pre-spill 1	–	16.7 ± 31.1	54.0 ± 78.4	49.3 ± 35.9	–	2.0 ± 9.8	6.7 ± 16.3	14.7 ± 33.0
	Pre-spill 2	19.3 ± 34.0	8.7 ± 14.1	24.3 ± 48.5	32.0 ± 46.5	30.7 ± 30.9	21.3 ± 20.4	19.5 ± 19.9	35.3 ± 45.7
	Post-spill 1	38.7 ± 51.9	5.3 ± 9.0	21.3 ± 17.4	13.6 ± 19.2	38.0 ± 47.1	17.3 ± 18.2	37.3 ± 51.2	20.1 ± 35.9
	Post-spill 2	59.4 ± 47.3	7.3 ± 9.4	108.0 ± 89.9	44.0 ± 85.1	27.3 ± 52.4	26.0 ± 33.0	56.0 ± 54.4	37.0 ± 40.6
	Post-spill 3	60.0 ± 58.8	12.0 ± 12.7	41.9 ± 48.8	64.3 ± 85.6	48.7 ± 49.6	32.7 ± 32.2	77.3 ± 95.3	70.0 ± 55.0
	Post-spill 4	56.7 ± 66.1	16.0 ± 28.3	–	9.3 ± 17.6	29.3 ± 31.5	22.7 ± 25.4	–	16.7 ± 20.3
Stenothoides spp.[3]	Pre-spill 1	–	8.7 ± 11.5	44.7 ± 66.2	32.0 ± 45.0	–	1.3 ± 4.5	13.3 ± 17.4	29.3 ± 45.2
	Pre-spill 2	56.0 ± 62.6	3.3 ± 8.1	19.5 ± 25.0	20.2 ± 31.9	3.3 ± 6.6	0.7 ± 3.3	4.9 ± 10.2	12.7 ± 19.4
	Post-spill 1	58.7 ± 55.8	7.3 ± 15.6	23.3 ± 23.6	96.1 ± 231.8	2.7 ± 7.7	0.7 ± 3.3	4.7 ± 8.8	11.8 ± 32.3
	Post-spill 2	92.0 ± 95.3	5.3 ± 10.2	52.7 ± 64.0	34.0 ± 46.2	14.8 ± 50.3	2.7 ± 6.1	8.0 ± 14.2	18.3 ± 51.4
	Post-spill 3	152.7 ± 116.9	6.7 ± 12.4	35.9 ± 45.7	26.0 ± 44.1	2.7 ± 6.1	1.3 ± 4.5	7.3 ± 11.5	24.0 ± 64.9
	Post-spill 4	373.5 ± 220.8	12.0 ± 17.8	–	179.5 ± 363.5	25.3 ± 28.3	7.3 ± 12.5	–	132.0 ± 311.0
Calliopiidae spp.[3]	Pre-spill 1	–	11.3 ± 24.3	38.7 ± 146.3	14.0 ± 33.8	–	0	1.3 ± 4.5	0
	Pre-spill 2	0.7 ± 3.3	0	1.4 ± 4.6	2.0 ± 7.2	1.3 ± 4.5	0.7 ± 3.3	3.5 ± 8.3	8.0 ± 29.8
	Post-spill 1	6.7 ± 9.3	2.7 ± 7.7	14.7 ± 25.8	56.1 ± 105.5	0.7 ± 3.3	0	26.4 ± 55.6	6.2 ± 28.1
	Post-spill 2	17.3 ± 37.7	2.0 ± 5.4	18.8 ± 24.4	17.3 ± 32.5	4.0 ± 16.5	0	6.0 ± 9.2	6.0 ± 13.2
	Post-spill 3	53.3 ± 64.8	28.0 ± 40.1	212.0 ± 239.5	76.8 ± 91.5	13.3 ± 39.4	7.3 ± 12.5	167.7 ± 263.5	70.0 ± 239.7
	Post-spill 4	38.8 ± 72.9	6.0 ± 17.5	–	24.0 ± 52.6	4.0 ± 10.8	0.7 ± 3.3	–	23.3 ± 62.1
Paroediceros lynceus	Pre-spill 1	–	5.3 ± 12.2	34.0 ± 72.4	11.3 ± 13.7	–	5.3 ± 10.2	42.0 ± 49.4	76.0 ± 92.1
	Pre-spill 2	2.7 ± 6.1	1.3 ± 4.5	18.8 ± 25.4	19.3 ± 35.0	4.7 ± 8.8	3.3 ± 8.1	13.9 ± 12.1	18.7 ± 28.2
	Post-spill 1	3.3 ± 9.4	2.7 ± 7.7	30.0 ± 42.3	13.6 ± 34.2	2.0 ± 7.2	3.3 ± 8.1	9.3 ± 11.5	32.0 ± 32.4
	Post-spill 2	17.3 ± 61.9	0.7 ± 3.3	69.3 ± 115.6	15.3 ± 32.2	2.0 ± 5.4	4.7 ± 8.8	20.0 ± 25.1	20.0 ± 23.7
	Post-spill 3	18.7 ± 52.7	2.0 ± 5.4	57.8 ± 105.3	38.4 ± 54.6	5.3 ± 10.2	9.3 ± 14.9	16.0 ± 21.1	33.3 ± 34.0
	Post-spill 4	0.7 ± 3.3	4.0 ± 10.8	–	4.7 ± 12.0	0.7 ± 3.3	3.3 ± 6.6	–	12.7 ± 18.9

APPENDIX R. Three-factor analyses of variance for the densities of dominant epibenthic crustaceans in three bays[1] at Cape Hatt, northern Baffin Island, during September 1980 and during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

Depth	Taxon	Source of Variation and df[3]: Period 4,6 or 30	Bay 2,6 or 30	Period x Bay[4] 8,6 or 30	Transect (Bay)[3] 6,313	Per x Trans (Bay)[3] 24,313
3 m	Total epibenthos	4.00 *	4.86 *	0.77 ns	13.38 ***	1.34 ns
	Amphipoda	5.60 **	3.47 *	0.86 ns	9.44 ***	1.04 ns
	Guernea sp.[6]	0.72 ns	16.11 **	0.44 ns	9.52 ***	1.66 *
	Stenothoidae spp.[6]	1.42 ns	19.39 ***	0.75 ns	3.92 ***	0.92 ns
	Calliopiidae spp.[6]	[5]	[5]	4.06 **	3.05 **	0.95 ns
	Anonyx spp.[6]	[5]	[5]	3.07 *	3.24 **	1.49 ns
	Orchomene minuta	0.54 ns	7.18 **	0.85 ns	8.70 ***	1.33 ns
	Monoculodes spp.[6]	1.24 ns	5.37 *	0.79 ns	5.98 ***	1.58 *
	Paroediceros lynceus	0.11 ns	2.40 ns	0.10 ns	15.87 ***	1.60 *
	Cumacea	1.40 ns	7.19 **	0.61 ns	17.00 ***	1.27 ns
	Lamprops fuscata	1.76 ns	7.39 **	0.66 ns	16.55 ***	1.09 ns
7 m	Total epibenthos	1.73 ns	0.52 ns	0.38 ns	8.79 ***	1.68 *
	Amphipoda	14.64 ***	19.81 ***	2.04 ns	1.60 ns	1.07 ns
	Guernea sp.[6]	13.13 ***	0.88 ns	0.90 ns	2.60 *	1.22 ns
	Calliopiidae spp.[6]	[5]	[5]	8.31 ***	0.86 ns	0.63 ns
	Anonyx spp.[6]	12.89 **	4.58 ns	2.15 ns	2.47 *	2.10 **
	Monoculodes spp.[6]	23.60 ***	5.73 **	1.75 ns	1.21 ns	1.00 ns
	Paroediceros lynceus	3.87 *	24.13 ***	1.41 ns	6.00 ***	0.59 ns
	Pontoporeia femorata	2.63 ns	8.00 **	0.53 ns	19.65 ***	1.51 ns
	Cumacea	3.52 *	46.23 ***	1.33 ns	0.91 ns	1.36 ns
	Lamprops fuscata	3.60 *	10.80 ***	1.53 ns	1.35 ns	1.02 ns
	Ostracoda (Myodocopa)	0.84 ns	1.20 ns	0.18 ns	13.21 ***	1.69 *

1 Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).

2 Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).

3 Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.

4 The Period x Bay term is the test of oil effects.

5 Interpretation of main effects confounded by significant interaction of Period x Bay term.

6 Stenothoidae includes *Metopella* and *Metopa*; Calliopiidae includes Apherusa. Genera indicated include species listed in Appendix C.

APPENDIX S. Three-factor analyses of variance for the densities of dominant epibenthic crustaceans in four bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

Depth	Taxon	Source of Variation and df[3]				
		Period 3,8 or 32	Bay 3,8 or 32	Period x Bay[4] 9,8 or 32	Transect (Bay)[3] 8,334	Per x Trans (Bay)[3] 24,334
3 m	Total epibenthos	2.83 ns	1.87 ns	0.24 ns	9.00 ***	1.84 *
	Amphipoda	5.04 *	1.33 ns	0.33 ns	5.69 ***	1.66 *
	Gurnea sp.[6]	0.94 ns	12.82 **	0.39 ns	8.26 ***	1.57 *
	Stenothoidae spp.[6]	2.61 ns	32.37 ***	1.61 ns	2.85 **	1.42 ns
	Calliopiidae spp.[6]	[5]	[5]	4.38 ***	1.89 ns	0.80 ns
	Anonyx spp.[6]	[5]	[5]	4.45 ***	1.54 ns	1.29 ns
	Orchomene minuta	0.93 ns	4.18 *	0.59 ns	6.70 ***	1.44 ns
	Monoculodes spp.[6]	3.32 ns	5.00 *	1.00 ns	4.39 ***	2.25 ***
	Paroediceros lynceus	0.36 ns	2.83 ns	0.12 ns	9.79 ***	1.86 **
	Cumacea	1.13 ns	6.38 **	0.54 ns	13.29 ***	1.15 ns
	Lamprops fuscata	1.19 ns	6.59 **	0.54 ns	12.84 ***	0.99 ns
7 m	Total epibenthos	6.27 **	2.89 ns	0.16 ns	6.42 ***	1.50 ns
	Amphipoda	18.09 ***	6.35 **	0.87 ns	2.28 *	1.22 ns
	Gurnea sp.[6]	11.37 ***	7.79 ***	0.80 ns	1.71 ns	1.18 ns
	Calliopiidae spp.[6]	[5]	[5]	6.38 ***	0.98 ns	0.73 ns
	Anonyx spp.[6]	3.95 ns	3.35 ns	1.18 ns	3.28 **	1.98 **
	Monoculodes spp.[6]	7.82 ***	2.71 ns	1.87 ns	1.71 ns	0.96 ns
	Paroediceros lynceus	0.96 ns	18.56 ***	0.81 ns	5.33 ***	0.71 ns
	Pontoporeia femorata	4.59 **	16.50 ***	0.48 ns	13.02 ***	1.46 ns
	Cumacea	3.45 *	34.95 ***	1.65 ns	1.51 ns	1.22 ns
	Lamprops fuscata	3.10 *	9.28 ***	1.63 ns	1.60 ns	0.96 ns
	Ostracoda (Myodocopa)	1.87 ns	5.83 **	0.19 ns	8.10 ***	1.41 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2 and 3 (September 1981, August 1982, September 1982).
[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.
[4] The Period x Bay term is the test of oil effects.
[5] Interpretation of main effects confounded by significant interaction of Period x Bay term.
[6] Stenothoidae includes *Metopella* and *Metopa*; Calliopiidae includes *Apherusa*. Genera indicated include species listed in Appendix C.

APPENDIX T. Three-factor analyses of variance for the densities of dominant epibenthic crustaceans in three bays[1] at Cape Hatt, northern Baffin Island, during August and September 1981 and 1982, and August 1983[2]. Transects are nested within bays. F-values are shown with significance levels (ns = P>0.05; * P≤0.05; ** P≤0.01; *** P≤0.001).

		Source of Variation and df[3]				
Depth	Taxon	Period 4,6 or 30	Bay 2,6 or 30	Period x Bay[4] 8,6 or 30	Transect (Bay)[3] 6,314	Per x Trans (Bay)[3] 24,314
3 m	Total epibenthos	1.83 ns	2.05 ns	0.23 ns	11.59 ***	1.94 **
	Amphipoda	3.40 ns	0.58 ns	0.34 ns	6.85 ***	1.99 **
	Guernea sp.[6]	7.15 ***	131.79 ***	1.78 ns	3.15 **	1.28 ns
	Stenothoidae spp.[6]	[5]	[5]	3.96 **	2.99 **	1.41 ns
	Calliopiidae spp.[6]	14.70 ***	9.06 ***	1.44 ns	3.04 **	0.91 ns
	Anonyx spp.[6]	[5]	[5]	4.42 **	2.41 *	1.50 ns
	Orchomene minuta	0.33 ns	1.21 ns	0.19 ns	7.50 ***	1.95 **
	Monoculodes spp.[6]	1.17 ns	6.07 *	0.74 ns	4.82 ***	1.91 **
	Paroediceros lynceus	1.96 ns	7.57 **	0.98 ns	6.97 ***	1.23 ns
	Osmacea	0.94 ns	14.64 ***	0.44 ns	13.93 ***	1.47 ns
	Lamprops fuscata	0.88 ns	15.00 ***	0.41 ns	13.65 ***	1.31 ns
7 m	Total epibenthos	2.43 ns	2.60 ns	0.08 ns	6.91 ***	1.82 *
	Amphipoda	7.31 *	8.66 *	0.24 ns	2.95 **	1.87 **
	Guernea sp.[6]	3.57 ns	5.51 *	0.14 ns	3.46 **	1.60 *
	Calliopiidae spp.[6]	5.39 **	6.37 **	0.47 ns	2.95 **	1.14 ns
	Anonyx spp.[6]	1.00 ns	3.41 ns	0.90 ns	3.31 **	2.06 **
	Monoculodes spp.[6]	4.81 **	1.37 ns	1.49 ns	1.92 ns	1.24 ns
	Paroediceros lynceus	2.38 ns	33.26 ***	0.86 ns	6.55 ***	0.63 ns
	Pontoporeia femorata	4.13 **	14.77 ***	0.30 ns	11.73 ***	1.40 ns
	Osmacea	4.43 **	37.30 ***	1.47 ns	2.70 *	1.36 ns
	Lamprops fuscata	5.03 **	8.16 **	1.40 ns	1.52 ns	1.32 ns
	Ostracoda (Myodocopa)	2.05 ns	14.30 ***	0.29 ns	8.53 ***	1.50 ns

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 11 (surface oil release).
[2] Pre-spill Period 2 (August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August 1983).
[3] Where Period x Transect (Bay) interaction was ns, it was pooled with Transect (Bay) effect to test Bay, Period and Period x Bay effects; where Period x Transect (Bay) was significant (P≤0.05), Transect (Bay) alone was used to test main effects.
[4] The Period x Bay term is the test of oil effects.
[5] Interpretation of main effects confounded by significant interaction of Period x Bay term.
[6] Stenothoidae includes *Metopella* and *Metopa*; Calliopiidae includes *Apherusa*. Genera indicated include species listed in Appendix C.

APPENDIX U. Mean biomass (g/m^2) of the 10 most abundant groups or species of macrophytic algae at 3 m depth in four bays[1] at Cape Hatt, northern Baffin Island, during September 1980, August and September 1981 and 1982, and August 1983[2]. Biomass expressed as mean ± SD of 10% formalin preserved wet weight and are based on 8 replicate 0.0625 m^2 airlift samples on each of three transects for each period and bay.

Species or Group	Period	Bay 7	Bay 9	Bay 10	Bay 11
Stictyosiphon tortilis	Pre-spill 1	-	60.83 ± 65.38	218.97 ± 177.62	145.67 ± 129.85
	Pre-spill 2	57.46 ± 40.08	42.04 ± 80.01	29.08 ± 34.40	328.89 ± 617.33
	Post-spill 1	43.69 ± 36.05	47.17 ± 82.31	38.52 ± 43.34	597.57 ± 1143.92
	Post-spill 2	142.16 ± 129.54	46.30 ± 79.21	214.03 ± 260.63	353.88 ± 391.35
	Post-spill 3	119.95 ± 121.55	40.58 ± 57.39	225.22 ± 351.58	779.54 ± 1284.41
	Post-spill 4	409.92 ± 353.20	190.67 ± 274.07	-	574.05 ± 379.02
Pilayella littoralis + diatoms[3]	Pre-spill 1	-	118.38 ± 56.19	231.10 ± 262.59	115.05 ± 149.53
	Pre-spill 2	60.83 ± 34.89	32.82 ± 28.14	41.24 ± 40.32	89.84 ± 131.67
	Post-spill 1	65.94 ± 57.87	48.80 ± 39.22	44.50 ± 50.57	196.52 ± 305.28
	Post-spill 2	44.24 ± 40.56	18.27 ± 23.66	81.88 ± 88.45	135.29 ± 184.34
	Post-spill 3	43.60 ± 52.01	30.73 ± 22.04	95.81 ± 90.37	93.97 ± 129.01
	Post-spill 4	46.03 ± 40.17	9.09 ± 13.81	-	141.57 ± 190.85
Dictyosiphon foeniculaceus	Pre-spill 1	-	66.63 ± 117.28	183.42 ± 183.06	2.86 ± 6.83
	Pre-spill 2	2.57 ± 2.51	15.13 ± 24.89	7.43 ± 8.18	0.87 ± 1.82
	Post-spill 1	4.46 ± 4.25	20.49 ± 32.45	15.17 ± 21.21	0.43 ± 0.67
	Post-spill 2	143.18 ± 159.71	7.20 ± 6.59	289.75 ± 345.68	5.25 ± 10.33
	Post-spill 3	161.39 ± 170.93	33.76 ± 31.86	184.70 ± 173.71	1.42 ± 2.43
	Post-spill 4	48.72 ± 34.67	13.43 ± 17.38	-	1.14 ± 3.02
Neodilsea integra	Pre-spill 1	-	0.91 ± 0.05	30.73 ± 97.71	0.18 ± 0.49
	Pre-spill 2	17.40 ± 44.40	<0.01	58.81 ± 160.10	1.46 ± 5.34
	Post-spill 1	13.85 ± 39.46	0	106.29 ± 254.24	1.32 ± 3.40
	Post-spill 2	36.24 ± 102.58	<0.01	32.10 ± 50.69	2.77 ± 6.10
	Post-spill 3	21.65 ± 43.93	<0.01	73.92 ± 162.83	0
	Post-spill 4	63.64 ± 106.02	0.18 ± 0.36	-	8.28 ± 39.24
Fucus distichus	Pre-spill 1	-	1.29 ± 2.82	8.34 ± 18.11	44.12 ± 91.82
	Pre-spill 2	8.31 ± 33.52	0.21 ± 0.95	8.37 ± 37.92	14.65 ± 25.52
	Post-spill 1	0.55 ± 1.47	0.81 ± 1.80	15.46 ± 50.46	38.29 ± 85.82
	Post-spill 2	8.81 ± 18.34	0.30 ± 0.54	25.48 ± 86.65	12.75 ± 31.92
	Post-spill 3	8.05 ± 32.84	4.61 ± 18.30	119.26 ± 241.02	10.54 ± 35.19
	Post-spill 4	7.40 ± 14.09	23.13 ± 68.94	-	39.98 ± 104.06
Laminaria spp.[4]	Pre-spill 1	-	2.44 ± 11.09	5.54 ± 19.29	1.22 ± 3.30
	Pre-spill 2	1.04 ± 4.39	0.08 ± 0.32	19.15 ± 36.00	7.21 ± 23.99
	Post-spill 1	<0.01	0.01 ± 0.07	65.43 ± 128.87	12.81 ± 21.68
	Post-spill 2	0.41 ± 0.91	0.01 ± 0.03	47.04 ± 64.14	33.07 ± 77.62
	Post-spill 3	0.20 ± 0.86	0	119.22 ± 239.50	17.23 ± 44.06
	Post-spill 4	2.03 ± 9.48	0.01 ± 0.03	-	39.39 ± 113.62
Sphacelaria spp.[4]	Pre-spill 1	-	1.16 ± 1.36	30.66 ± 72.37	14.92 ± 24.32
	Pre-spill 2	1.08 ± 1.12	0.39 ± 0.54	13.96 ± 17.18	5.19 ± 7.44
	Post-spill 1	1.03 ± 1.24	0.65 ± 0.73	8.92 ± 14.83	16.50 ± 29.83
	Post-spill 2	3.04 ± 3.96	0.59 ± 1.18	38.22 ± 44.95	33.48 ± 53.53
	Post-spill 3	3.14 ± 4.28	0.68 ± 0.92	51.98 ± 74.26	59.38 ± 173.86
	Post-spill 4	7.40 ± 9.70	1.23 ± 1.45	-	60.66 ± 173.61
Chorda spp.[4]	Pre-spill 1	-	30.83 ± 29.97	5.13 ± 17.73	1.22 ± 3.17
	Pre-spill 2	0.11 ± 0.28	0.03 ± 0.05	0.03 ± 0.10	<0.01
	Post-spill 1	4.32 ± 8.62	3.12 ± 4.25	0.22 ± 0.67	0
	Post-spill 2	0.07 ± 0.26	0.15 ± 0.41	0.13 ± 0.28	<0.01
	Post-spill 3	0.44 ± 1.45	9.62 ± 14.18	1.07 ± 2.04	0.28 ± 0.94
	Post-spill 4	0.20 ± 0.53	0.02 ± 0.06	-	0
Chaetomorpha spp.[4]	Pre-spill 1	-	0.03 ± 0.07	2.91 ± 6.16	4.48 ± 9.77
	Pre-spill 2	0.09 ± 0.14	0.01 ± 0.04	1.42 ± 1.90	5.81 ± 8.71
	Post-spill 1	0.07 ± 0.18	0.01 ± 0.03	1.25 ± 1.85	20.71 ± 36.40
	Post-spill 2	0.27 ± 0.68	0.04 ± 0.08	5.54 ± 6.80	27.33 ± 41.84
	Post-spill 3	0.16 ± 0.24	1.19 ± 5.27	6.63 ± 9.75	43.90 ± 86.56
	Post-spill 4	0.27 ± 0.60	0.10 ± 0.18	-	65.15 ± 70.06
Punctaria glacialis	Pre-spill 1	-	0.45 ± 1.60	0	0
	Pre-spill 2	2.52 ± 5.16	0.11 ± 0.38	0.15 ± 0.47	0
	Post-spill 1	12.39 ± 16.58	0.86 ± 3.30	0.86 ± 2.47	0
	Post-spill 2	24.40 ± 50.55	0.97 ± 3.07	0.64 ± 1.34	0.12 ± 0.57
	Post-spill 3	12.40 ± 18.22	0.27 ± 0.87	11.74 ± 26.50	0.26 ± 1.13
	Post-spill 4	25.55 ± 38.69	0.95 ± 1.98	-	0.75 ± 1.89
Total algae[5]	Pre-spill 1	-	288.20 ± 161.56	765.77 ± 643.56	347.39 ± 333.91
	Pre-spill 2	154.26 ± 82.51	91.43 ± 112.54	187.46 ± 191.10	477.66 ± 762.82
	Post-spill 1	148.76 ± 102.67	124.12 ± 133.52	315.70 ± 311.30	940.86 ± 1483.13
	Post-spill 2	405.42 ± 403.83	74.66 ± 100.50	743.58 ± 702.06	627.05 ± 670.36
	Post-spill 3	372.20 ± 308.38	123.78 ± 92.37	907.84 ± 796.98	1032.63 ± 1595.16
	Post-spill 4	612.94 ± 423.03	239.18 ± 304.60	-	986.43 ± 670.57

[1] Bay 7 (reference), Bay 9 (dispersed oil release), Bay 10 (dispersed oil contamination), Bay 11 (surface oil release).
[2] Pre-spill Periods 1 and 2 (September 1980, August 1981) and Post-spill Periods 1, 2, 3 and 4 (September 1981, August 1982, September 1982, August? 1983).
[3] P. littoralis and tubular diatoms not separated.
[4] Genera listed include species listed in Table 20.
[5] Includes other species not weighed individually.